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Bring on the Real Computer Revolution

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> You know, Phaedrus, that's the strange thing about writing, which makes it truly analogous to painting. The painter's products stand before us as though they were alive: but if you question them, they maintain a most majestic silence. It is the same with written words... once a thing is put in writing...when it is ill-treated and unfairly abused it always needs its parent to come to its help, being unable to defend or help itself. (Plato)

A few months ago, game designer Nicky Case and 'recreational mathemusician' Vi Hart published an article entitled "Parable of the Polygons." They described economist Thomas Schelling's model of the dynamics of segregation – in Schelling's model, a segregated society spontaneously emerges, even though individuals in the society all mean well. Case and Hart called it a *playable* post; the post included living simulations of what the nearby prose was explaining. As Case and Hart explained a rule of the model, the reader could intuitively understand the rule by playing with and handling the simulation. Compare their piece to Schelling's original article from 1971, "Dynamic Models of Segregation." Both attempt to teach the reader Schelling's segregation model, but they use different media: Schelling reduces the system into prose, expecting and hoping that the reader can expand it, while Case and Hart break nothing off – the reader handles the model right on the page.

When our ancestors became literate, they made a sort of trade: they gave up their powers of memory, and they gave up the connection between their knowledge and the physical environment around them. They gave up active dialogue between the learner and the teacher. But as Walter Ong discusses in his book *Orality and Literacy,* they became able to track resources on paper, to run bureaucracy, to remember things outside themselves, and to work with formal notation (Ong, 1982; Konnikova, 2015). Our non-literate predecessors might say we've crippled ourselves, but that deal is the foundation of our society and of our values, especially here in academia.

With computers, we can renegotiate that trade; authors can finally write living texts. And since personal computing is such a new technology, we've only had a couple of decades to work out what we can do. Gutenberg did not foresee the effects of the printing press within his lifetime; early printed books were directly modeled on manuscripts

(Eisenstein, 1982). Similarly, computers have mostly been used to duplicate existing media so far: 'TV, but more flexible'; 'Books, but easier to distribute.' The only works which really depend on computing technology today are video games, but making games demands serious engineering effort – imagine if an author had to design fonts, typeset, bind, and print their books by hand. The authors of video games are the select few who can do both authoring and engineering, and they have blind spots. For example, video games are almost all fictional. We don't even have terms for nonfiction or non-narrative games, so the people who could be writing the great works of the computer medium don't even know that this field exists. This future of dynamic creation will only happen if we intentionally pursue it, and if we bring this potential to the attention of all kinds of creators. As the computer scientist and graphical interface pioneer Alan Kay likes to say, "the real computer revolution hasn't happened yet" ("The Computer Revolution," 2007). If we focus on solving only obvious and immediate problems, on making what we do in offices and at home easier and more productive, then the revolution might take much longer, or not happen at all.

This agenda isn't new—in fact, it's why we have personal computers in the first place. The architects of the personal computer era, people like Ted Nelson, Douglas Engelbart, and Alan Kay, set out to *augment human intellect*, to save the world by building tools to, in Kay's words, "amplify human reach, and bring new ways of thinking to a faltering civilization that desperately needed it" (Engelbart, 1962; Kay, *The Early History of Smalltalk,* 1993). They weren't driven by market forces or by the desire to build things; they weren't hackers or entrepreneurs in a traditional sense. They had a normative vision in mind, of a new medium and new thinking, and the world that they could enable (Victor, 2012). They believed that the computer medium would bring deep understanding of complicated ideas to everyone, even little kids (Kay & Goldberg, 1977). They argued that computer simulations of knowledge would promote understanding of *systems*, unlike books and television, which filter understanding through linear stories.

Besides Case and Hart's piece, we have a few other concrete examples of how computing could be a medium for understanding systems. The drafters of the Constitution spent months building a structure for a government, then crunched it down into a skeletal prose description. The Constitution is a static document, but it actually describes a dynamic system with various interacting pieces. The Constitution, when read, might prompt any number of questions from the reader, but the document can't respond to those questions; it is fixed once written, just as Plato said. If its drafters had computers and the right authoring tools, Alan Kay argues, they could have encoded the system directly in a living document, a simulation for people to play with and understand ("Revealing the Elephant," 1996). Authors who stumbled on this vision have written preliminary, fumbling, but fascinating interactive texts for programming

language theory (Pierce, 2015), geometry (Disseldorp, 2013), and electrical engineering (Schaedler, 2015). But these are singular works that took an unsustainable amount of individual effort, and they're just a start. Every idea deserves this treatment, even ideas that aren't mathematical or scientific models.

Still, these prototypes of the new medium are interesting in two ways. First, they represent concepts in more than one form. Where most texts have prose explanations and formal notation, these 'books' also render objects visually; they show a network graph for a system of flows, sources, and sinks; they show charts of any useful data. Second, they give the reader fast feedback; as Bret Victor says of his ideas for creative tools, "creators need an immediate connection to what they're creating" (Victor). Ideally, the reader sees what they want to know without doing anything. But if the system is too complicated to be fully shown, then at least when the reader twists a knob, what appears on the screen twists at the same time. If you see '3 + x = 4', you should also see that 'x = 1', without having to do algebra on paper. And if you tweak that equation, you should see the new value of 'x' right away. The traditional computer program makes the reader plug all the parameters in, then pull a lever, before seeing any output, because our tools make that kind of interactivity easier to develop. These two principles encourage the reader to play around and build intuition for the idea. You can't learn how to play an instrument just by reading a textbook; you have to use the system to understand it.

Technologists sometimes meet up with humanists or social scientists, and they talk about how computers can serve humanistic purposes. It’s a perfect opportunity to build stories and systems that use this new medium. We could move beyond demonstrations of concepts from computer science and think about how to represent qualitative ideas. But these discussions inevitably turn into discussion of *data* (Wardrip-Fruin, 2012). Yes, that's an obvious and useful place for engineers to help humanists, but it's a remarkably narrow subset of what computers can really do. It's as though everyone decided the printing press was only good for printing bibliographies, charts, and tables, or as though writing was only good for keeping tax records. Computing could be as fundamental as writing is for the humanities, and we should set our research agenda in that direction. Why shouldn't an ordinary political scientist or historian in the future, one who doesn't work with data at all, write their thesis as an interactive text? Treating computing as a medium, rather than as just a tool for data processing, broadens these interdisciplinary discussions.

How can we create this future of living text? If you're a humanist, don't think of computers as a novelty: would you think of literacy that way, as something divorced from the important questions of human life? Try tools like Twine and Scratch and Processing, which bridge the gap between literacy and programming; do your work (whether it's creative or analytical or anything else) with these new forms in mind. If you're an engineer, don't think like a 1950s mainframe operator; don't think that the

only contribution of computer technology is data analysis. Build tools that open up the medium to authors and expand people's creativity, or make interactive works yourself. Whatever you do, you don't need to wait: the next time you need to do a project for a class, or write a paper, or participate in a hackathon, or design an interface for work or make tools to help yourself, think about how computers can express systems, and think about how to give your audience intuition for what's going on. For instance, if you're an urbanist, make a simulation and animate your paper model of how cities work. You don't need to 'learn to code.' Use the tools you're comfortable with, but keep these principles in mind. Look for new representations and places where fast feedback can help. Learn about the work of Kay, Engelbart, Victor, and many others who have started this agenda. Talk to people inside and outside your community about these ideas. People will create things, and then we'll pull principles out of them, and then we'll have a field. The first step is to make people aware of this vision.

My own background is in programming, so I've done work in programming languages, on developing formalisms and tools that support this future. I made a 'calculating notepad' that lets an author type in algebraic constraints and then brings the system to life (Rizwan, Cruncher, 2015). I've found, however, that like many programmers, I have a bias toward building very general tools that don't have an obvious use. Instead, I now start with a specific area I understand, and then use these principles to see that area differently. This vision, much like writing, is applicable anywhere: I've implemented some of Kay's ideas for the Constitution, and I've begun working on an interactive interface for digital logic (Rizwan, personal website, 2015). This field is massively underexplored, and there are inventions waiting to be made and principles waiting to be set out.

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