Codex, Memex, Genex: The Pursuit of Transformational Technologies

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ABSTRACT

Handwritten codexes or printed books transformed society by allowing users to preserve and transmit information. Today, leather-bound volumes and illuminated manuscripts are giving way to animated image maps and hot links. Vannevar Bush's memex has inspired the World Wide Web, which provides users with vast information resources and convenient communications. In looking to the future, we might again transform society by building genexes -- generators of excellence -- to support creative exploration of ideas. Thesauri are to words, as genexes are to ideas. Such inspirational environments would empower personal and collaborative creativity by enabling users to:

- collect information from an existing domain of knowledge,
- create innovations using advanced tools,
- consult with peers or mentors in the field, and then
- disseminate the results widely.

This paper describes how a framework for an integrated set of software tools might support this four-phase model of creativity in science, medicine, the arts, and beyond. Current initiatives are positive and encouraging, but they do not work in an integrated fashion, often miss vital components, and are frequently poorly designed. A well-conceived and clearly-stated framework could guide design efforts, coordinate planning, and speed development.

Keywords

Genex, memex, World-Wide Web, advanced graphical user interfaces, computer supported cooperative work, information visualization

INTRODUCTION

Computer professionals have much to be proud of in the past fifty years. We have developed a scientific discipline, a remarkable technology, and a thriving industry. Computing, information, and communications technology have transformed aviation, automobiles, medicine, publishing, banking, and many more areas. These transformations will continue but as we look forward to the next fifty years, we may consider a more planful process in shaping the applications of our maturing technology and in dealing with many serious problems facing our civilization.

Early transformational technologies include paper and printing, which are referred to by the term "codex" in the title of this essay. Durable books and movable type reshaped science, religion, politics, and daily life in many ways. Ensuing information technology innovations included photography, telephony, radio, and television. Then, in July 1945 President Roosevelt's science adviser, Vannevar Bush described memex, for "memory extender." In his essay on grand projects that scientists might work on as World War II was coming to an end, he proposed a personal desktop system, based on microfilm technology, that would provide access to historical sources for domains such as patents, legal citations, or scientific papers. The vision of memex as a personal workstation was a powerful force in shaping the development of personal computers, our work on hypertext, and the emergence of the World-Wide Web.

Later visions from J. C. R. Licklider helped launch digital libraries, which he saw as a centralized resource that could be accessed electronically. Licklider was profoundly influenced by Bush's vision and dedicated his book to Bush. Douglas Engelbart's powerful notions of intelligence augmentation by advanced user interfaces and Computer Supported Cooperative Work were key inspirations for the personal computer and groupware. The theme of collaborative tools to support scientific research stimulated William Wulf to coin the term "collaboratories" in his 1989 white paper.

Personal computing and network access have already become widespread in some countries, and will spread further as prices decline, user interfaces become more well designed, and services become more relevant. Universal service is an important goal to pursue, so that the benefits of computing and communications are available to all who seek them. There is a growing risk that advancing technology will widen the gap between rich and poor, and produce further disadvantages for poorly educated citizens. Progress is needed in low-cost manufacturing techniques, convenient public services, improved training, and effective support. But even as these improvements are being made, it may be useful to think further ahead to grander goals that may constructively transform society.

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Foundational Beliefs	Creative Phases	Genex Tools
1) New knowledge is built on previous knowledge	Collect information from an existing domain of knowledge	Digital libraries, Search services, Dynamic queries, Information visualization, Multimedia search
2) Powerful tools can support creativity	Create innovations using advanced tools	Document assemblers, Art, design & architecture tools, User interface builders, Simulations, Models, Templates, History, Macros
3) Refinement is a social process	Consult with peers or mentors in the field	Listservs, Newsgroups, Conferencing, Groupware, Presentation, Annotation, Tele-democracy
4) Creative work is not complete until it is disseminated:	Disseminate the results widely	Email, Electronic publications, Narrowcasting, Affiliation networks, Niche lists, E-communities

Table 1: Genex framework: Foundational beliefs are tied to creative phases and existing tools that can be refined and integrated into a genex.

We should move beyond the modest goal of getting a computer to perform as well as the best human being, and pursue tools that enable humans to perform a thousand times better than the most capable human. Printing presses, photography, and electronic mail satisfy this test, but foreseeing the next innovation is difficult.

The first steps towards building new tools may already be appearing in advanced software packages and on the World Wide Web. Creative designers are introducing environments that go well beyond the vision supplied by Bush, Licklider, Engelbart, and Wulf. They prefigure tools that are more than a digital library or intelligence amplifier; they support creativity. I might call such a tool *memex 2.0*, to suggest an expansion of Bush's memex, but I prefer *genex*, to indicate an orientation towards *generating excellence*. (Note: The closeness of genex to genetics and to generation-X is coincidental.) This may be an optimistic expectation, but it conveys my belief that well-designed technologies can promote excellence. Users who experience empowering designs that are comprehensible, predictable, and controllable, may be inspired to pursue quality in their work products.

A genex would be an integrated family of tools that supports users in creating innovations in art, science, engineering, etc. A genex would help users initiate hopes, fabricate plans, and implement dreams in a highly social framework. It would facilitate dialog with peers and mentors, and then dissemination to potential beneficiaries. The current initiatives are positive and encouraging, but they do not work in an integrated fashion, often miss vital components, and are frequently poorly designed. A well-conceived and clearly-stated framework could guide design efforts, coordinate planning, and speed development.

Appropriate genex designs would enable problem solvers to locate and build on previous work easily, explore numerous alternatives rapidly, consult conveniently, and propagate solutions widely (Table 1). Inevitably there will be many genexes; oriented towards different domains and tailored to the needs of different users, such as eager students acquiring a domain, methodical workers in existing domains, or visionary explorers of new domains.

The four phases of creativity-- collect, create, consult, and disseminate -- can stimulate a research program to take current user interfaces to the next stage. The rapidly growing World-Wide Web is already a remarkable resource, but in the next fifty years it might grow by a factor of a thousand more users (from 10^7 to 10^{10}) and a million times in data volume (from 10^8 pages to 10^{14} pages). These changes plus the increased expectations of users means that more effective designs will be needed.

CONCLUSION AND CAUTION

Creativity is often described as a rare experience for elite workers, but genexes can promote contributions from more diverse individuals to ever widening domains of knowledge. Initial steps are appearing on the World Wide Web, there is little coordination and many designs lack vital components.

Many versions of genex are likely to be built, capturing the history of each domain, tailored to the needs of each field, and in harmony with the working styles of diverse individuals. Some genexes are likely to be too restrictive in their support of creativity or too limited in their functionality, but the examples of excellence should help to promote quality. Progress in implementing a genex will be measured by the number of adopters and their productivity, but progress as a civilization will be harder to measure.

No one can guarantee that genex technologies will be applied in positive ways, but novel social structures that encourage participatory design and open discussions may more regularly lead to higher societal benefits. Each professional's contribution to societal transformation becomes an inspiration and he or she becomes a role model for others. Every story we tell about one person making a difference inspires the next constructive contribution.

We live in a troubled world, with immense problems that are not caused by technology: conflict and oppression, poor health and nutrition, inadequate housing or sewage, illiteracy and poor education, and many more. Computing and communications technology may contribute to solutions by enabling people to explore a wider set of alternatives, consult easily with peers and mentors, and record their successes (and failures) so others can learn from them. Our greatest resource is human creativity. Appropriate technology can empower more people to experience the thrill of creative work and enable each of us to make a difference.