Establishing a framework of activities for creative work.

Creativity Support Tools

Developing software tools to support creativity is an ambitious, but some would say, vague goal. Charles Cave's famous Web site on creativity reviews 62 diverse creativity support tools, including enhanced thesauri to elicit related terms and prompt fresh ideas, concept map managers to support playful exploration in two-dimensional layouts, and guided writing programs to support story and screenplay development [1]. These exemplars are helpful, but to make more rapid progress creativity support tool designers could benefit from a clearer set of requirements. A starting point is to identify the users and types of user activities to be addressed.

Who are the users? Software support seems most realizable and beneficial for innovative scientists, doctors, lawyers, musicians, artists, teachers, or other knowledge workers who struggle with problems in recognized domains of work. The widespread desire to produce scientific papers, patient treatment plans, legal briefs, and popular songs, means there could be a substantial audience for effective tools. These domains of work (physics, medicine, law, music) also have associated fields of people who act as gatekeepers, such as scientific journal editors, music critics, or art museum curators. They validate creative contributions according to accepted, although often debated, standards of quality. The goal of designing creativity support tools is to make more people more creative more often, enabling them to successfully cope with a wider variety of challenges and even straddle domains. Some tasks may be routine, such as doing computations or searching databases, while others require innovative leaps to identify associations, discover correlations, or recognize opportunities.

What user activities need support? Many methods for promoting creative work have been proposed ranging from structured work plans to disruptive set-breaking scenarios. Daniel Couger [2] reviewed 22 "creative problem solving methodologies" with simple plans such as Preparation, Incubation, Illumination, Verification. Couger offers his own plan with five phases:

- Opportunity, delineation, problem definition;
- Compiling relevant information;
- Generating ideas;
- Evaluating, prioritizing ideas; and
- Developing an implementation plan.

These plans were inspirational for me, but I was seeking a method tied more closely to implementable software. Secondly, I was influenced by Csikszentmihalyi's analysis that emphasized the social nature of creativity [3]. He stresses the benefits of consultations with other domain experts, receiving empathic encouragement from emotional supporters, and the necessity for dissemination within the field.

After several years of exploration, I adopted a framework [6] with these four activities (Figure 1):

- **Collect:** Learn from previous works stored in libraries, the Web, and other sources.
- **Relate:** Consult with peers and mentors at early, middle, and late stages.

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- **Create:** Explore, compose, and evaluate possible solutions.
- **Donate:** Disseminate the results and contribute to libraries, the Web, and other sources.

These four activities do not form a linear path. Creative work may require a return to earlier phases and much iteration. For example, libraries, the Web, and other resources may be useful at every phase. Similarly, creative people may want to have discussions with peers and mentors repeatedly during the development of an idea. The social processes that support consultation can also be helpful to them at early, middle, and late stages of the creative process.

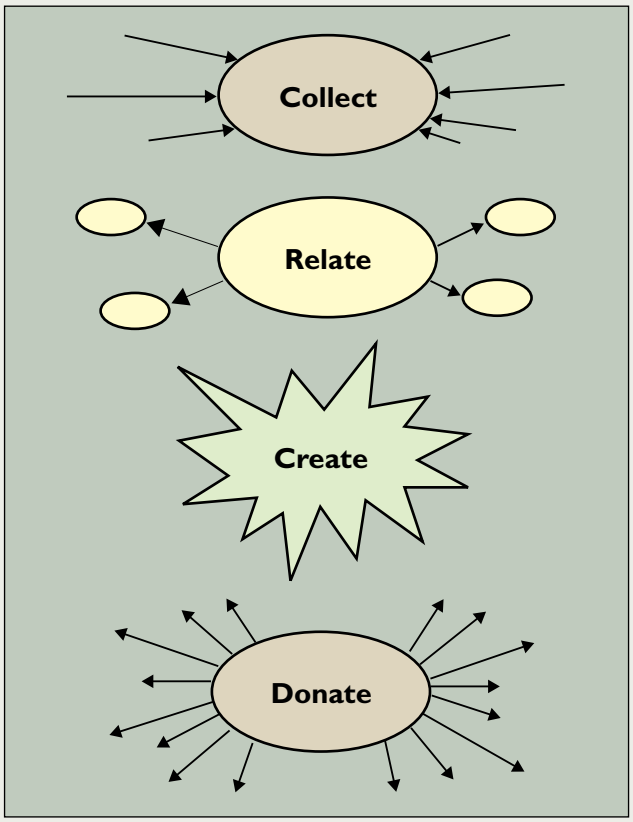

Figure 1. Four activities in the creativity framework: Collect-Relate-Create-Donate.

When innovators come up with something new, they often seek to disseminate it to others. This makes it available for the next person to build on and learn from. Personal computing technologies coupled with networking have made patents, legal decisions, scientific papers, music, poetry, novels, and many other creative works available online. However, we are still far short of having access to all of these materials because of financial limitations, copyright issues, and business models that seek to profit from creative work.

Problem solving and creativity are often portrayed as lonely experiences of wrestling with the problem, breaking through various blocks, and finding clever solutions. Consultation with others and dissemination of the results is minimally mentioned. Some reconsideration of such methodologies is already under way because of the presence of the Web. It has already dramatically reduced the effort of finding previous work, contacting experts, consulting with peers and mentors, and disseminating solutions.

Integrating Creative Activities

The Collect-Relate-Create-Donate framework will work more effectively if multiple creativity support tools can be conveniently applied to a problem. Some of these tools already exist, but could be enhanced to better support creativity. However, the main challenge for users and designers is to ensure smooth integration across these novel tools and with existing tools such as word processors, presentation graphics, email, databases, spreadsheets, and Web browsers.

Smoother coordination across windows and better integration of tools seem possible. Just as word processors expanded to include images, tables, annotations, and more, the next generation of software is likely to integrate additional features. The first aspect of integration is data sharing and it can be accomplished simply by providing compatible data types and file formats. Users should be able to import weather data from a Web page into a forecasting program so they can make their own predictions. Users should be able to download a song and put it into a composition tool so they can read the notes and make their own variation or use it as back-

ground for a video. Of course users might have to pay for the right to do this with charges added to phone or Internet bills.

A second aspect of integration involves compatible action patterns and consistent terminology. Most computer users are familiar with patterns of actions such as cut-copy-paste or open-save-close. Higher levels of actions might be candidates for inclusion in the next generation of tools, such as annotate-consult-revise or collect-explore-visualize. Until these functions become available in standard tools users will have to adopt careful working styles to accomplish these goals.

For example, one devoted family photographer created photo collections with captions of who was in each photo and a record of the event (annotate). She sent these as email attachments to a word processor file and 25 photo files to family members for their comments, reminiscences, and stories (consult). Then when they sent back their comments by email, she deleted the least-liked photos and added the best comments (revise) into a final album that was archived as a set of Web pages. This was a complicated task that took time and expertise beyond what many users are capable of doing. However, if there was a specific tool to support the annotate-consult-revise process for photo libraries, more people could consistently produce creative results that captured family personalities. Of course annotate-consult-revise can also be applied to scientific papers, musical compositions, or architectural drawings.

Similarly, another sequence that needs software support is collect-explore-visualize to let users gather family genealogies, sales information, or book citations. Users should be able to describe their needs, such as family information, and then invoke a search task (collect) to gather information from multiple Web sites and libraries. Next they could review the result sets, selecting some, rejecting others, and putting some aside for later review. Finally, they could visualize the results in a family tree, a historical timeline, or on a world map.

A third aspect of integration is the smooth coordination across windows. For example, if users see an unfamiliar term in a Web page, they should be able to click on it and get an English definition, a French translation, or a medical dictionary report, all in a predictable screen location. Similarly, if they find a personal name in a news report they should be able to get a biography, email address, or contact information. Such tools are available, so users can set up some of the services, but more ambitious tools could be even more helpful. If users have a map of a city, they should be able to click on landmarks and get explanatory Web sites, travel directions, or location diagrams. If they select a region they should be able to get the demographics of the population living there, a listing of the entertainment events, or photos on a timeline showing the history. Of course, the ambition can be even greater. They might want to click on one of the photos and get biographies of the people in the photo or the complete archive of the photographer. Smooth coordination enables users to rapidly pursue connections and is likely to lower the barriers to creative activities.

(1) Searching and browsing digital libraries, the Web, and other resources
(2) Visualizing data and processes to understand and discover relationships
(3) Consulting with peers and mentors for intellectual and emotional support
(4) Thinking by free associations to make new combinations of ideas
(5) Exploring solutions—What-if tools and simulation models
(6) Composing artifacts and performances step-by-step
(7) Reviewing and replaying session histories to support reflection
(8) Disseminating results to gain recognition and add to the searchable resources

Figure 2. Eight tasks to support creativity.

Eight Tasks

I propose eight specific tasks that should help more people be more creative more of the time (Figure 2). I can't prove these eight tasks are a complete set, but they can help as a checklist for designers of software tools. The four activities—Collect, Relate, Create, Donate—can be accomplished by repeated applications of the eight tasks (Figure 3). Users can apply existing general-purpose software tools to support these eight tasks, but specially tailored products in each domain of work will be more effective.

Searching remains a hot topic for many researchers who are proposing improved search tools for special media such as photos, videos, music, or maps, or based on special needs such as shopping, travel, or health care. Searching libraries, the Web or other resources accelerates collection of information about previous work. Users may also need to search in order to find consultants or to decide on candidate communities for disseminating of results.

Visualization tools are just making the transition from research ideas to commercial successes with examples such as the Map of the Market (see www.smartmoney.com), Spotfire (see www.spotfire.com), and improved mapping software. Visualizing objects and processes is the task that could appear as part of any of the four activities. Drawing mental or concept maps of current knowledge helps

users organize their knowledge, see relationships, and possibly spot what is missing.

Relate. Consultation tools start with email, chat, and instant messenger applications. However, specialized forms of exchange are needed that guide participants to clarify requests while ensuring credit for and protecting new ideas.

Thinking. Once users have identified a problem and are working on solutions, there are at least four tasks that come up in many discussions of creativity. The most common task is thinking by free association, sometimes called brainstorming. Another popular term, coined by Edward de Bono, is lateral thinking, which he defines as "exploring multiple possibilities and approaches instead of pursuing a single approach" [4]. Many creative people appreciate tools that support their free association that helps to break free from their current mind set. Some software tools have attempted to do this by providing related concepts textually as in the IdeaFisher that provides capabilities that go beyond the usual thesaurus. The developer believes creative thinking is an associational process and offers a tool to show words that are related to an initial thought by many cross-reference paths. Users of IdeaFisher offer spirited testimonials to the enjoyable, useful, and sometimes surprising results.

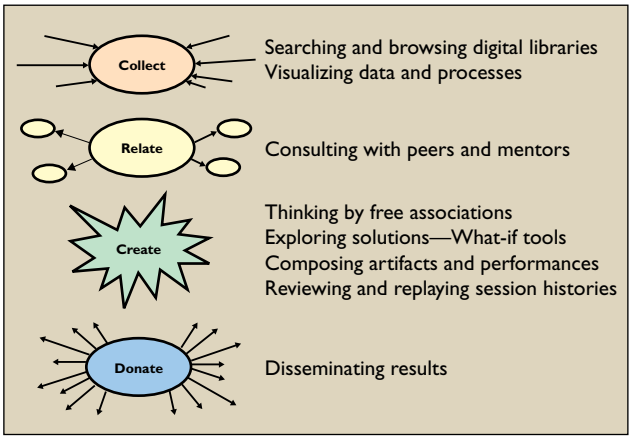

Figure 3. Primary relationships of four activities and eight tasks.

Exploring. Another important task during creative exploration is to conduct thought experiments about the implications of decisions. Software tools to support this task have matured in many fields. For example, spreadsheets allow users to explore the implications of changes to a business plan, a school budget, or a population growth estimate. More sophisticated tools for simulations have been introduced in every field. These let users set the initial values, try alternative scenarios, and watch what happens. Simulation models have been applied to models of world economies, growth of forests, and collisions of stars. Simulations open users minds to possibilities, allow them to explore safely, and enable them to see complex relationships. Simulations can even be fun, and popular, such as the game-like SimCity, which enables users to playfully explore urban planning issues (see www.simcity.com).

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Composition tools include the ubiquitous word processor for composing documents or poems, and elaborate music editing programs to write symphonies or rock tunes. Graphics composition tools show the enormous power of software to enable more people to be more creative (see the article by Terry and Mynatt in this section). Slide presentations are now widely used, even by elementary school children, and photo editing tools have enabled many people to crop, retouch, enhance, and combine their photos. A compelling composition tool is Dramatica Pro for writing complex movie scripts (see www.dramatica.com). It is built on a remarkable theory of story telling and character development that guides users in telling and refining their story. The successive versions and add-ons to this tool show how software can provide remarkable support for creative productions. Dramatica Pro provides an excellent inspiration for ways to enhance current composition tools to more directly support innovation.

Reviewing. One of the features to be added to many software tools, history keeping, is the capacity to record activities, review them, and save them for future use. This list lets users return to previous steps, much like the back button on the Web browser. But the history-keeping tools I have in mind will also let users edit, store frequent patterns of use, and replay histories. Users can also send a history to peers or mentors to ask for help. There is growing evidence that such tools help users and learners in many ways.

Disseminating. Finally, when users have created something they like, they need to disseminate it. Some people will be happy just to send email to a

few friends, but more ambitious possibilities are attractive. During searching tasks, as users collect information for their work, they encounter Web sites and work of many people. So now it might be useful to be able to send acknowledgment to all the people whose work was influential. Filters to capture all the email of those people could help users disseminate their work to people who might be interested. An even more ambitious idea would be to send email announcements to all the people who had visited the same Web sites they visited. The danger of spam grows quickly, so ways to enable users to specify their interests and willingness to receive unsolicited email must be part of such designs. A more gentle approach is to install work on a Web page and add entries to indexes that others can explore. Then they can decide about downloading a creative contribution.

I repeat that these eight tasks are not a perfect and complete set, but they may be helpful in analyzing existing software and in designing new tools.

The Skeptic's Corner

It seems necessary to address the hubris or arrogance of proposing technology to aid human creativity. A critic might scowl that creativity is inherently human and no computer could or should be brought into the process. But technology has always been part of the creative process, whether in Leonardo's paint and canvas or Pasteur's microscopes and beakers. Supportive technologies can become the potter's wheel and mandolin of creativity—opening new media of expression and enabling compelling performances. Just as sewing machines facilitated fashion and telescopes sped progress in astronomy, new creativity support tools will broaden participation and accelerate innovation in many domains.

At the revolutionary end of creativity spectrum, support tools could also facilitate the kind of breakthroughs that Einstein, Picasso, Freud, or Stravinsky made in their fields [5]. However, their paradigm-shifting historical contributions were about breaking rules and creating new domains of work, so it may be difficult to develop commonly used tools.

My expectations are largely positive, but there are many problems, costs, and dangers in anything as ambitious as creativity support tools. An obvious concern is that many people may not want to be more creative. Many cultures encourage respect for the past and discourage disruptive innovations. Promoting widespread creativity raises expectations that may change employment patterns, educational systems, and community norms. Introducing computer support for creativity may produce greater social inequality as it raises the costs for those who wish to participate. More rapid exploration may inhibit some creative personalities who prefer a "calm computing approach" (to use Mark Weiser's term) and more reflective mood. Finally, these tools may be used equally by those who have positive and noble goals as well as by dictators, terrorists, or criminals who seek to dominate, destroy, or plunder.

These fears are appropriate and reasonable cautions must be taken, but support for innovation could lead to positive changes to our world. However, the moral dilemma of technology innovators remains troublesome: How can I ensure that the systems I envision will bring greater benefits than the negative side effects that I dread and those that I fail to anticipate?

The path from high expectations to practical action is not easy, but examples of how information technologies helped identify ozone depletion by remote sensing, improved medical diagnosis with computer-aided tomography, and enabled bans on nuclear tests are encouraging. Ensuring more frequent positive outcomes and minimizing negative side effects remain challenges, but a framework that provides for substantial consultation and broad dissemination may help. C

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