# Introduction to Workshop Report

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> *As Galileo struggled to view Jupiter through his newly built telescope, he adjusted the lenses and saw four twinkling points of light nearby. After recording their positions carefully, Galileo compared them to his drawings from previous nights. His conclusion that Jupiter had four moons circling it was a profound insight with far reaching implications.*

Paradigm shifting breakthroughs make for great stories, but normal science is equally important in the evolutionary development of science, engineering, and medicine. Large and small breakthroughs are often made by scientists, engineers, designers, and other professionals who have access to advanced tools. The telescopes and microscopes of previous generations are giving way to advanced user interfaces on computer tools that enable exploratory search, visualization, collaboration, and composition.

Creativity, innovation, discovery, and exploration are potent concepts in academic communities, leading companies, and visionary circles. Enthusiasts envision accelerating innovation through advanced science collaboratories, design environments, open source communities, and knowledge management tools. They promote idea generation and brainstorming tools for divergent thinking followed by knowledge organization and concept mapping software for convergent processing. Testimonials from developers and users celebrate rapid genomic database search, shared astronomy laboratories, open physics preprint archives, and potent engineering design tools. Similar enthusiasm flows from users of compelling screenwriting software, flexible music composition packages, and impressive video-editing software.

The promise of making more people more creative more of the time is compelling, but research on creativity support tools is just beginning. Proposed support tools are meant to serve individuals as they grapple with problems, as well as cross-disciplinary teams working in close collaboration even when separated by distance. Even more ambitious is the provision of social creativity support tools for larger communities working in rich socio-technical environments over longer time periods. Expectations are high and belief in beneficial outcomes is great, but much work remains to be done to develop a respected academic discipline with validated results.

Interest in creativity is growing. Computing companies, such as Hewlett-Packard feature ‘innovation’ as their expertise, while Intel and Microsoft present appealing television commercials that promise to empower young minds with technology (‘Your potential, Our passion’). Consulting companies claim expertise and software entrepreneurs promote products with little more than testimonial support. Websites promote a range of creativity support tools, novel processes, and educational seminars.

A small number of cognitive and computer scientists, information systems researchers, and industrial designers have begun to develop theories and software tools that may have widespread benefits, but their

work could be dramatically accelerated with increased research support. These researchers often focus on serving professionals such as business decision makers, biologists exploring genomic databases, designers developing novel consumer products, or children in (and out of) classrooms. At the same time there is a history of collaborative projects between technologists and new media artists, musicians, poets, and writers that are inspiring new tools. Another lively source of ideas is from innovative educational environments for children and students. For each of these projects novel research methods could also accelerate our understanding of what software improvements are needed.

The workshop report includes two major sections that discuss research methods that are appropriate for studying creativity support tools and initial guidelines for the design of creativity support tools. The audience for this report includes research managers in government, industry, and universities, as well as researchers interested in exploring these new directions. Additional sections cover:

- the relationship to work of new media artists, indicating what can be learned from this community that strongly identifies with the notions of creative work products
- the role of search tools and information visualization
- a survey of efforts around the world related to creativity tools
- a set of seven issues discussed during the workshop
- a review of creativity and distributed intelligence
- a set of future research directions

The remainder of this introduction reviews current thinking about creativity and describes the workshop outcomes.

**Current thinking about creativity**

The potential for enhancing human creativity has been a recurring theme of visionary thinkers such as Edward DeBono whose 'lateral thinking' ideas have had a warm reception, internationally, but a cool reception from academics. Dan Couger's review of 22 creativity methods included the classic ones such as the methods described by Hadamard, reporting on Poincare: Preparation, incubation, illumination, verification. Recent variations, include these design steps for engineering (Adams et al., 2003, Atman et al., 2003):

- Problem definition – identify need
- Gather information
- Generate ideas – brainstorm & list alternatives
- Modeling – describe how to build
- Feasibility Analysis
- Evaluation – compare alternatives
- Decision – select one solution
- Communication – write or present to others
- Implementation

During the past decade respected psychologists who work on creativity, such as Mihaly Csikszentmihalyi (his books include the widely cited *Creativity* (1996) and *Finding Flow*(1997)), have given a more compelling foundation. Csikszentmihalyi made two major contributions. First, his structured interviews with 91 creative people (Nobel and Pulitzer Prize winners, leading artists, corporate gurus, etc.) led to a thoughtful characterization of three key components for understanding creativity:

1) **Domain**: e.g. mathematics or biology, "consists of a set of symbols, rules and procedures"
2) **Field**: "the individuals who act as gatekeepers to the domain...decide whether a new idea, performance, or product should be included"
3) **Individual**: creativity is "when a person... has a new idea or sees a new pattern, and when this novelty is selected by the appropriate field for inclusion in the relevant domain"

This characterization focuses on the individual but clearly makes creativity a social process, since an individual's work becomes creative only when judged by others. Csikszentmihalyi's second contribution was the development of the concept of *flow* which is a state of mind in which an individual is performing skilled work at an appropriate level of challenge between anxiety and boredom. Individuals in the flow state are focused on their task and moving towards their goal, often with little awareness of their surroundings. They are less aware of time, often spending hours deeply engaged in their challenge. While flow is not directly tied to creativity, many people engaged in creative tasks report being in such a flow state.

Robert Sternberg's remarkable edited collection, the *Handbook of Creativity* (1999), has drawn popular and academic interest. This *Handbook*, and numerous other books, provide useful intellectual foundations concerning motivations, strategies, and assessment for human creative work. A particularly appealing chapter by Nickerson offers 12 steps to teaching creativity:

- Establish Purpose and Intention
- Build Basic Skills
- Encourage Acquisition of Domain-specific Knowledge
- Stimulate and Reward Curiosity and Exploration
- Build Motivation
- Encourage Confidence and Risk Taking
- Focus on Mastery and Self-Competition
- Promote Supportable Beliefs
- Provide Balance
- Provide Opportunities for Choice and Discovery
- Develop Self Management (Meta-Cognitive Skills)
- Teach Techniques and Strategies for Facilitating Creative Performance

All of these discussions of creativity are helpful, but we propose to push forward by focusing on creativity support *tools* that promote, accelerate, and facilitate creativity. Just as Galileo and Jefferson employed telescope and pantograph, contemporary innovators use computer-based software tools. We see compelling opportunities for dramatic improvements of tools for work in the sciences, engineering, medicine, knowledge work, humanities, arts, and beyond.

Since many descriptions of creativity focus on the individual, it is important to balance this view with an appreciation of the importance of supporting creativity in small teams and larger communities. Scientific papers in mature fields such as physics and biology often have teams consisting of dozens of authors from multiple disciplines who contribute to a research result.

Creativity has been rightly recognized as a key to economic growth and social transformation in the well-document analysis by Richard Florida (2002), *The Rise of the Creative Class and How It's Transforming Work, Leisure, Community and Everyday Life*. His later work *The Flight of the Creative Class* (2005)

makes the case even stronger, positing a global future shaped by communities that lure creative people by emphasizing the 3 T's: Technology, Talent and Tolerance. If Florida's thesis is valid, then developing technologies that support and amplify creative talents could have a massive impact. Just as physicists were lured to facilities that provided powerful synchrotrons and astronomers came to work where the best telescopes were available, future creativity support tools will entice the most innovative minds and enable them to accelerate the pace of discovery and innovation.

Some commentators believe that creativity is the domain of the rare individual who arises only a few times in each century. This older notion celebrates historic figures such as Newton, Einstein, or Edison, but newer thinking proposes that every person can become creative. Eric von Hippel's *Democratizing Innovation* (2005) argues that "users of products and services -- both firms and individuals -- are increasingly able to innovate for themselves." He focuses on manufacturing and product development, but the capacity of individuals to be creative grows as the software tools spread to diverse disciplines. The first generation of business software such as spreadsheets, database management, email, and web services changed the face of industry and created a global marketplace. The impact of improved software tools is also clearly visible in filmmaking, digital photography, video editing, and music composition. The next generation of these tools will have an even stronger impact as the number of users grows dramatically from few million to a few billion people.

Awareness of the benefits of focusing on creativity comes from the National Academy of Sciences report *Beyond Productivity: Information Technology, Innovation and Creativity* (2003), which argues that the challenge for the 21st century is to "work smarter, not harder." This report and others identify the impact of creativity support tools on global competitiveness, successful civic infrastructures, scientific leadership, and educated citizenry.

**Workshop Goals**

In assembling a group of leading researchers and graduate students, we sought to create a new community of interest around creativity support tools for individuals, teams, and communities. We believed the workshop on creativity support tools could:

1) **Accelerate the process of disciplinary convergence:** Creativity support tool research must bridge multiple disciplines including computer science, psychology, human-computer interaction, information systems, information visualization, and software engineering. Researchers from one discipline may not appreciate the relevance of and rarely reference outside their discipline, thereby failing to take advantage of progress already made by others. Promoting awareness of interdisciplinary work would accelerate progress for all and improve quality.

   Developing an understanding of how work in one discipline is useful to another would help advance the research process. A natural task is to reframe computer science research on user interface building tools and on collaboration technology as contributions to creativity support.

2) **Promote rigorous research methods:** The commercial promoters of current creativity support tools emphasize testimonials rather than research results. Attempts to apply controlled experimentation have been only marginally successful, because lab-like settings and toy-like tasks are fundamentally at odds with the goals of innovative thinking. Rigorous research methods in creativity research will have to be developed because insight, discovery, and innovation are so

difficult to asses. Researchers will benefit from development of appropriate benchmark tasks and replicable evaluation methods.

3) **Increase the ambitiousness of research programs:** Creativity support researchers have proposed theoretical frameworks and innovative ideas that are slowly being refined through testing with small groups of users. With increased funding these projects could grow and researchers could grapple with more significant design issues. Also establishing an effective community of researchers will enable more extensive collaborations and support larger scale projects.

We believed that existing guidelines can be refined and applied to improve many software tools. Such tools are one of computer science's most fruitful contributions, amplifying the skills of millions of users through word processors, email, web browsers, spreadsheets, and graphics programs. Current tools are merely the first generation, which now can be enhanced with richer creativity support features.

**Workshop Outcomes**

The lively discussions before, during and after the workshop indicate that there are compelling issues for discussion. One participant made the memorable statement in his opening presentation: "I have been studying collaboration for 20 years, but have only thought of creativity for two hours." Post workshop comments by email emphasized the fresh perspective, such as this comment from a respected senior researcher: "Absolutely the most stimulating meeting I have been to in long time." Another participant wrote "A magnificent effort to bring together such a diverse range of people and then have them align their research so well along a single axis." And finally one of the graduate students commented "very stimulating and energizing … I had trouble falling asleep… because my head was filled with new ideas… I left with dozens of pages of notes to follow up on in my own research."

Maintaining such enthusiasm is difficult, especially in this community of active researchers who are engaged in multiple projects. Another challenge is the interdisciplinary nature of this work, and the need for intense longitudinal case studies. Initiating new research directions is difficult, but the topic of creativity support tools could gain ground if there were acknowledgement for its importance among funding agency leaders.

The authors of this report seek to promote interest in creativity support tools by accelerating the process of disciplinary convergence. We aspire to bridge computer science, HCI, psychology, and related disciplines to encourage ambitious research projects that could yield potent tools for many people to use. We came to a consensus about the outcome that would:

- **Accelerate research and education on creativity support tools by:**
  - Making the case for increased funding for creativity support tool research
  - Encouraging investment in substantial multi-year longitudinal case studies
  - Proposing ways to create greater interest among researchers, students, policymakers, and industrial developers.
  - Provide appropriate software infrastructure and toolkits so that creativity support tools can be more easily built.
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- **Promote rigorous multidimensional evaluation methods by:**
  - Understanding the benefits and limits to controlled experimentation

- Developing observation strategies for longitudinal case studies
- Collecting careful field study, survey, and deep ethnographical data

- **Rethink user interfaces to support creativity by offering guidelines for:**
  - Design tools for individuals and socio-technical environments for groups.
  - Promote low thresholds, high ceilings, wide walls, and powerful history-keeping
  - Support exploratory search, visualization, collaboration, and composition

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