Chapter 11
Design and Creativity

The intuitive mind is a sacred gift and the rational mind is a faithful servant. We have created a society that honors the servant and has forgotten the gift.

– Albert Einstein

Abraham Maslow once said "The key question isn't 'What fosters creativity?' But it is why in God's name isn't everyone creative? Where was the human potential lost? How was it crippled? I think therefore a good question might be not why do people create? But why do people not create or innovate? We have got to abandon that sense of amazement in the face of creativity, as if it were a miracle if anybody created anything."

Every designer is creative. In the world of software design, we also create artifacts. Where does this creativity come from? What exactly is meant to be creative? In this chapter we explore questions such as these. We also take a brief look at the creativity literature and discuss how information technology tools can help humans become more creative and vice versa.

11.1 Creativity – What Is It?

Creativity typically involves doing something that is novel and the production of some artifact judged by domain experts, in some manner, to be creative and of value. We see creativity manifesting itself in art, in science, and in everyday life.

The potential for enhancing human creativity has been studied by visionaries such as De Bono (1973), whose "lateral thinking" ideas have been widely taught in industry. Couger (1996) in his work cites 22 creativity methods some of which are preparation, incubation, illumination, and verification.

Recently we see synergies in creativity steps with those in engineering design as illustrated in Adams et al. (2003):

- Problem definition – identify need
- Gather information
- Generate ideas – brainstorm and list alternatives

A. Hevner, S. Chatterjee, *Design Research in Information Systems*, Integrated Series in Information Systems 22, DOI 10.1007/978-1-4419-5653-8_11,

- Modeling – describe how to build
- Feasibility analysis
- Evaluation – compare alternatives
- Decision – select one solution
- Communication – write or present to others
- Implementation

In the past decade, psychologists such as Mihaly Czikszentmihalyi have given as foundation to better understand creativity. Through his two widely cited books (*Creativity,* 1996 and *Finding Flow,* 1997), he posits three key components for understanding creativity:

1. Domain (e.g., mathematics, music) "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. His second contribution is the idea 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. Once in the state of flow, they are highly focused and move closer to their goal, often with little awareness of their surrounding. Creative people are often reported to be in a state of flow.

Another notable work is Robert Sternberg's "*The Handbook of Creativity*" (Sternberg 1999). One of the chapters 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 (metacognitive skills)
- Teach techniques and strategies for facilitating creative performance

11.2 Group Creativity

The only constant in this world is change. It could be argued that the basis for much of this change stems from stimulating effects of new ideas and creativity. Most research and writing on creativity has focused on individual creativity with little acknowledgement of group factors that influence the creative process. The lack of attention to group factors in the creativity field is consistent with much evidence in the literature that groups may inhibit intellectual activity or optimal performance. Feeling pressured to come up with consensus (Janis 1982), groups can lower accountability (Karau and Williams 1983) and groups tend to focus on common rather than unique ideas (Strasser et al. 1989). Despite all this, research on minority influence in group contexts has shown that creative thought in other domains is increased as minority views are introduced in a group setting (Nemeth et al. 1992).

The main proponents of group creativity are those who promote teamwork and innovation in organizations (Bennis and Biederman 1997; Osborn 1963). Even though there has been an increasing awareness of the importance of social, cultural, contextual, and organizational factors in creativity, there has thus far been much less systematic focus on the group processes related to creativity. This is a serious problem since increasingly creative achievements require the collaboration of groups or teams (Dunbar 1997).

A decade ago, the general belief was that groups should not be used for creativity due to process loss (Stroebe and Diehl 1994). However, at this time, we know that groups can achieve high levels of creativity and even outperform their best resource in the group. At the information age, it is simply impossible for one person to possess all the necessary knowledge in solving a problem. Reliance on others with a variety of experiences and backgrounds is imperative. In addition, creativity is socially defined (Csikszentmihalyi 1996) and creative ideas should be evaluated and accepted by others as creative ideas in the first place.

It is in light of recent developments in the field of creativity and the need to better understand and maximize group creativity that this is an ongoing and active research field. Researchers have contributed to the creativity domain in terms of both face-to-face group creativity and distributed group creativity. There are indications that electronic groups hold some promise for stimulating higher levels of creativity, especially when the groups are large (Dennis and Williams 2003). There is also evidence that electronic groups do better than face-to-face groups when it is critical to share unique knowledge (Lam and Schaubroek 2000). There is no doubt that there are potential benefits associated with collaboration either in the face-to-face or the electronic means; however, efficient procedures are required to fully benefit from group interaction in promoting creativity.

Convergent thought may have a place in efficiency, but it is unlikely to aid the generation of creative ideas (Hackman 1990). Creativity generally requires novelty, plus appropriateness in solving problems (Amabile 1983). Creativity at the level of idea generation is associated with added flexibility and divergent thinking

patterns (Guilford 1950). Flexibility involves thinking in different conceptual categories. However, in the process of group creativity which leads to development of a new product or process or generation of a new way of thinking, there must also be convergent thinking. At some point the group must decide on a course of action and implement the new outcome. This constant sequencing between divergent thinking process and convergent thinking process is the skill that the group members must learn and do well at.

11.3 Conceptual Blockbusting Theory

As part of addressing the efficiency issues associated with group creativity, one should consider the conceptual blockbusting framework (Adams 2001). Adams' perspective is that creativity is not something that creative people possess as an "add-on." Instead he argues that each person has the opportunity to reach his potential by focusing on removing the barriers to their creativity.

Jim Adams has contributed tremendously by identifying and categorizing barriers to creativity. These barriers are identified as conceptual blocks. He categorizes the main blocks as perceptual, emotional, cultural, and intellectual. In the later chapters of his book, he suggests strategies for removing these conceptual blocks.

Perceptional Blocks: These are kinds of mental inflexibility. These are obstacles that prevent the problem solver from clearly perceiving either the problem itself or the information needed to solve the problem. Some of these difficulties include the following:

- Stereotyping – seeing what you expect to see; stereotyped seeing and premature labeling are all common
- Difficulty in isolating the problem
- Tendency to delimit the problem area poorly (imposing too many constraints)
- Inability to see the problem from various viewpoints
- Saturation (mind can only record a limited number of inputs)
- Failure to utilize all sensory inputs (graphical and physical media)

Emotional Blocks: These are barriers that stem from inherent human emotions.

- Fear of taking a risk
- No appetite for chaos is driven by an overriding desire for order
- Judging rather than generating ideas
- Inability to tolerate ambiguity
- Unwillingness to incubate – people often cannot relax ("sleep on it")
- Excessive zeal – having over-motivation to succeed quickly can only see one direction to go (ours)
- Reality versus fantasy
- Of flow and angst

Cultural Blocks: They are acquired by exposure to a set of cultural patterns. Sometimes they get codified into law and are not challenged as society changes. They include the following:

- Taboos
- Fantasy and reflection are waste of time, lazy, and even crazy
- Playfulness is for children only
- Reason and intuition do not help
- Left-handed versus right-handed thinking
- Everybody should be just like me

Environmental Blocks: They primarily stemm from an individual's or group's setting. They include the following:

- Distraction such as phone or e-mail interruptions
- Lack of support to bring ideas into action
- Lack of cooperation and trust among colleagues due to insecurity in job
- Accepting or incorporating criticisms
- Lack of a supporting work environment
- Autocratic boss who only values his own ideas does not reward others
- Inhibiting organizational management styles

Intellectual and Expressive Blocks: These stem partly from lack of domain state-of-the-art knowledge and partly due to weak expressive skills. Examples include the following:

- Individual or group may lack the updated information or even correct information
- Inflexible or inadequate use of intellectual problem-solving strategies
- Formulating problem in incorrect language (e.g., verbal, math, visual)
- Inadequate language skills to express ideas
- Expressive communication across disciplines, admitting ignorance

In his work on creativity, James Adams asserts that removal of creativity blocks contributes to increased creativity. He identifies a variety of blocks such as those elaborated above. Adams' work examines these blocks in relation to an individual. But the idea of conceptual blocks, specifically divergent and convergent thinking patterns, can be applied in relation to groups, namely how would groups deal with conceptual blocks? What strategies must be used in overcoming these blocks? What other factors impact "group" blockbusting when compared to "individual" blockbusting?

11.4 Experiential Learning

Learner-centric education has gained enormous popularity in recent years and institutions of higher education are in the midst of trying to redefine and reinvent their course offerings in a manner that is consistent with this ideal. The experiential learning theory (Kolb and Fry 1975) for many decades has used the principle of the learner as "a creator of learning" rather than the "passive recipient of information." Experiential learning method considers individual student as the focal point for learning while the expert acts as the facilitator to guide this learning process. This method has proved to be very effective in many teaching situations and in particular in teaching "soft skills" in business administration.

David Kolb and Roger Fry developed "the experiential learning model" composed of four elements:

- concrete experience
- observation of and reflection on that experience
- formation of abstract concepts based upon the reflection
- testing the new concepts
- repeating the experience

These four elements are the essence of a spiral of learning that can begin with any one of the four elements, but typically begins with a concrete experience. This model was developed predominantly for use with adult education but has found widespread pedagogical implications in higher education.

11.5 Creativity, Design, and IT

There is growing interest in creativity today and within the scientific community a desire to design and build IT tools that promote, accelerate, and facilitate creativity (Shneiderman 2006). Richard Florida's recent work *The Rise of the Creative Class* (Florida 2002) points out the fact that creativity is critical to economic prosperity and social transformation. Since 2003, there has been a renewed interest on creativity support tools and understanding their design issues. Shneiderman organized a successful NSF workshop (Shneiderman 2006) which brainstormed on what those design requirements should be. One of the outcomes of that workshop is a set of "design principles," sometimes called patterns, to guide the development of new creativity support tools. These principles support exploration and provide an open environment with low threshold, high ceiling, and wide walls to capture many paths and styles that support collaboration. These tools should be simple, easy to navigate, allow reflection, provide iteration capability, and become a design for designers (Support Tools 2005).

The set of "design principles," sometimes called patterns, can guide the development of new creativity support tools (Shneiderman 2006). What distinguishes these

principles from other user interface principles is that they emphasize easy exploration, rapid experimentation and fortuitous combinations that lead to innovations:

1. Support exploration
2. Low threshold, high ceiling, and wide walls
3. Support many paths and many styles
4. Support collaboration
5. Support open interchange
6. Make it as simple as possible – and maybe even simpler
7. Choose black boxes carefully
8. Invent things that you would want to use yourself
9. Balance user suggestions with observation and participatory processes
10. Iterate, iterate, and then iterate again
11. Design for designers
12. Evaluate your tools

Referring back to Maslow's opening quote, why are not more people creative? The creativity computer science community has been engaged in answering this question (Greene 2002). Many strongly believe that today we are at the cusp of technology which can facilitate creative thinking and help produce creative artifacts. But these tools and technology should be designed well. The design principles are a first set of guidelines. More recently, Schneiderman has proposed eight tasks that should help people to be more creative more of the time.

1. Searching: It has been noted that creative people are good at knowing what is out there. Collecting what is out there is a first step toward creating something novel. The World Wide Web has made search easy and today one can look up photos, text, voice, images, videos, music, maps, and works of art by a single click on the search engines. This has accelerated the collection of vast amount of information. It has also enabled finding consultants or gatekeepers of a field when it is time to disseminate your creative work.
2. Visualization: Visualizing data and processes to understand and discover relationships is an essential part of creative work. Drawing mental or concept maps of current knowledge helps users organize their knowledge, see relationships, and possibly spot what is missing.
3. Relate: Consulting with peers and mentors is important. Today it is facilitated by chat, SMS, e-mail, and videoconferencing. Exchange of ideas and bouncing of possible alternatives are enabled quite easily with IT tools today.
4. Thinking: Once a problem has been identified, researchers start to work toward possible solutions. As mentioned before, "brainstorming" is a necessary activity during this phase. Edward de Bono calls this lateral thinking, which he defines as "exploring multiple possibilities and approaches instead of pursuing a single approach."
5. Exploring: As the solution matures, creative people often need to understand the consequence of their decisions and trade-offs. Simulation tools can help here.

Simulations open users minds to possibilities and help answer what-if type of questions.
6. Composition: Tools are very much in use today. The ubiquitous word processor, music editing software such as Cubase or ProTools, graphics composition tools, and slide presentation tools are extremely useful composition tools. New tools should be designed that let users work out their artifacts or performances step by step.
7. Reviewing: Replaying session histories to support reflection is important. The capacity to save previous versions is useful which lets users get back to previous stages.
8. Disseminating: Results are disseminated in the final stage to gain recognition. Users want their work to be part of the searchable collection of resources.

Today, there is active research being conducted within the CS & IT community that is exploring the intersection of information technology, design, and creativity.

11.6 Creativity and Design in the Age of Virtual Worlds

Virtual worlds are computer-maintained environments that provide 3D visual and auditory displays; environments that allow movement and interaction by a human using some control scheme (Singhal and Zyda 1999). Virtual worlds, if designed properly, provide the illusion that the interacting human is "in world" (Bartle 2003). We can create any imaginable environment and we can experience entirely new perspectives and capabilities within it. Virtual worlds originally were built in the mid-1980s as research environments using expensive workstations. By the mid-1990s, commercial videogames began to appear that had better-looking, well-produced worlds. Virtual worlds began to be networked routinely about 1987 (Singhal and Zyda 1999) with that networking providing the extra dimension in the virtual world of other humans with whom one could interact. Early virtual worlds were pretty silent but commercial games today provide at least chat and many voice-over-IP (Chatterjee et al. 2005) capabilities. Games are basically virtual worlds for which a participatory story has been designed, a story whose purpose is to entertain the player. The underlying technology for games and virtual worlds today is basically the same (Zyda, 2007).

The growth rate for virtual world utilization stands at 15% per month with no foreseeable slowdown (Gartner 2008). This is the same with research being carried out in virtual worlds. It is an ever-increasing way for business and governments to use the resources to gather and collate information for their use (Carless 2007). Here we provide brief examples of various uses of virtual worlds in academia and commerce:

- Immersive exhibits in Second Life that allow residents to engage in, experience and respond to information in context, allowing for a deeper understanding of places, situations or circumstances. The UC Davis Virtual Hallucinations facility

in Second Life is designed to give visitors a better understanding of schizophrenia by simulating the experience of the visual and aural hallucinations associated with schizophrenia based on interviews with real schizophrenics (Yellowlees and Cook 2006).

- Governments are also beginning to interact in virtual worlds and discussions in terms of governance and law are taking place inside these worlds. Virtual worlds are neither public nor privately owned. It is the people interacting in it that make the world.
- Many companies and organizations now incorporate virtual worlds as a new form of advertizing. There are many advantages to using these methods of commercialization. An example of this would be Apple creating an online store within "Second Life."
- Using virtual worlds gives companies the opportunity to gauge customer reaction and receive feedback. Feedback can be crucial to the development of a project as it will inform the creators exactly what users want.
- Another use of virtual worlds in business is where you can create a gathering place. Many businesses can now be involved in business-to-business commercial activity and will create a specific area within a virtual world to carry out their business. Within this space all relevant information can be held. This can be useful for a variety of reasons. You can conduct business with companies on the other side of the world, so there are no geographical limitations; it can increase company productivity. Knowing that there is an area where help is on hand can aid the employees. Sun Microsystems has created an island in Second Life dedicated for the sole use of their employees. This is a place where people can go and seek help, exchange new ideas, or to advertize a new product.

While still low in numbers, current examples do exist of how virtual worlds are impacting education (Maher 1999; Anderson 2006). Many high schools are taking advantage of virtual worlds, using them to work with other schools or study things and places that otherwise they would never be able to see. Some colleges are accepting the use, creating campuses and providing classes in Second Life (Antonacci and Modaress, 2005). Although very few elementary level educators see the benefits of the revolutionary learning tool, but the possibilities are there for the youngest of students as well. Studying biology? Why not go inside a cell or traverse the DNA highway? Virtual worlds provide these opportunities to students of all ages. A good compilation of educational uses of Second Life can be found at http://sleducation.wikispaces.com/educationaluses.

11.7 Designing Virtual Worlds

How might virtual worlds provide new opportunities for enhancing human creativity? A lot depends on the creativity of the designers. Eventually virtual worlds will permeate into every aspect of life. Virtual worlds and collaborative games hold a great potential for study as laboratories of creativity. The reason for that is that these environments have the potential to be fully instrumented with the actions inside of

them recorded for later study and playback. Participants can interact in these environments within the boundaries set by the world/game creators and we can peer at these actions from across the network as both observers and participants.

Bricken (2008) provides insight into how a paradigm shift needs to take place when we are dealing with designing virtual worlds.

- From interface to inclusion: While in the past designers have focused on the interface, a boundary between information environment and person accessing the information (e.g., monitor screen), in virtual world design, the focus should be on inclusion, the ability to get inside the information. An important design consideration stemming from inclusion is that while we interact within a virtual world, we simultaneously inhabit the physical world.
- From mechanism to intuition: Virtual world technology adapts computers to human functioning, rather than training people to cope with interactions based on the computer's mechanism. The task of designing a virtual world then does not rest on helping people interpret what the machine is doing, but on determining the most natural and satisfying behaviors for particular participants and providing tools that augment natural abilities.
- From user to participant: Among software developers, the term user refers to the generic person who, at the end of the programming and interface design process, receives a software application geared to "average" human functioning. Participants are active agents. Sensory coupling requires us to regard each participant as an individual and individuals are highly idiosyncratic.
- From visual to multimodal: Most virtual worlds are 3D, acoustigraphic environments with stereoscopic head-mounted display. These capabilities require designers to consider the issues of sensory load related to individual learning and performance styles.

11.8 Conclusion

All designers need to be creative. Where does that creativity come from? One school of thought says that creativity is innate, i.e., god given. You are either born with it or not. Recent school of thought challenges that notion. The current thinking is that creativity can be fostered and enhanced. With modern information technology, the basic steps of creative thinking can be significantly enhanced. This remains an active research field.

It is still an open question how to measure the extent to which a tool fosters creative thinking? HCI professionals are used to measuring the effectiveness and efficiency of tools, but how do you measure if it supports creativity? Evaluation is difficult because traditional controlled studies are inappropriate and brief case studies are not adequate. To measure creativity, one could look at the various outputs produced. One can comment on the viability of outputs and designs but it is still

difficult to get at the quality of solutions. Current thinking is that one would need multi-dimensional long-term case studies to gain deep insights.

Creativity and design go hand in hand. The current activities on what IT can do to enhance creativity will create new tools in the future. That in turn will affect the way we do design. We see an exciting future ahead.

References

Adams, J. (2001) *Conceptual Block-Busting, A Guide to Better Ideas*, 4th edn, Da Capo Press, Cambridge, MA.

Adams, R. S., Turns, J., and Atman, C. (2003) Educating effective engineering designers: The role of reflective practice. *Design Studies* 24, pp. 275–294.

Amabile, T. (1983) *The Social Psychology of Creativity*. Springer-Verlag, New York.

Anderson, T. (2006) An Educator Discovers his Second Life. Virtual Canuck. Accessed at http://terrya.edublogs.org/2006/07/17/an-educator-discovers-his-secondlife/

Antonacci, D. M. and N. Modaress (2005) Second Life: The Educational Possibilities of a Massively Multiplayer Virtual World (MMVW), Educause. URL: http://www2.kumc.edu/tlt/SLEDUCAUSESW2005/SLPresentationOutline.htm

Bartle, R. A. (2003) *Designing Virtual Worlds*, New Riders, Indianapolis, IN.

Ben Shneiderman et al. (2006) Creativity support tools: Report from a U.S. National Science Foundation sponsored workshop. *International Journal of Human Computer Interaction*, 20 (2), pp. 61–77.

Bennis, W. and Biederman, P. W. (1997) *Organizing Genius: The Secrets of Creative Collaboration*, Addison-Wesley, Reading, MA.

Bricken, M. (2008) Virtual Worlds: No Interface to Design – Technical Report R-90-2, University of Washington, Seattle.

Carless, S. (2007) Informa predicts $58.4B game industry in 2007. Gamasutra (Oct. 24, 2005) www.gamasutra.com/php-bin/news_index.php?story=6942 .

Chatterjee, S., T. Abhichandani, B. Tulu, and H. Li (2005) SIP-based enterprise converged network for voice/video over IP: implementation and evaluation of components, *IEEE Journal on Selected Areas in Communications (JSAC)* 23, pp. 1921–1933.

Couger, D. (1996) *Creativity & Innovation in Information Systems Organizations*, Boyd & Fraser, Danvers, MA.

Csikszentmihalyi, M. (1996) *Creativity: Flow and the Psychology of Discovery and Invention*, HarperCollins, New York.

Csikszentmihalyi, M. (1997) *Finding Flow: The Psychology of Finding Engagement with Everyday Life*, Basic Books, New York.

De Bono, E. (1973) *Lateral Thinking: Creativity Step by Step*, Harper, New York.

Dennis, A. R. and M. L. Williams (2003) Electronic Brainstorming: Theory, Research, and Future Directions, in P. Paulus (ed.), *Group Creativity*, Oxford University Press, Oxford.

Dunbar, K. (1997) How Scientists Think: Online Creativity and Conceptual Change in Science, in T. B. Ward, S. M. Smith, and J. Vaid (eds.), *Creative Thought: An Investigation of Conceptual Structures and Processes*, American Psychological Association, Washington D.C., pp. 461–493.

Florida, R. (2002) *The Rise of the Creative Class and How Its Transforming Work, Leisure, Community and Everyday Life*, Basic Books, New York.

Gartner (2008) Virtual Worlds To Have 'Transformational Business Impact', April 2008, http://www.worldsinmotion.biz/2008/08/gartner_virtual_worlds_to_have.php

Guilford, J. P. (1950) Creativity, *American Psychologist* 5, pp. 444–454.

Hackman, J. R. (ed.) (1990) *Groups that Work (and Those that Don't)*, Jossey-Bass, San Francisco.

Janis, Irving L. (1982) *Groupthink: Psychological Studies of Policy Decisions and Fiascoes*, 2nd edn, Houghton Mifflin, New York.
Karau, S. L. and Williams, K. D. (1983) Social Loafing: A meta-analytical review and theoretical integration, *Journal of Personality & Social Psychology* 65, pp. 681–706.
Kolb, D. A. and Fry, R. (1975) Toward an Applied Theory of Experiential Learning, in C. Cooper (ed.) *Theories of Group Process*, John Wiley, London.
Lam, S. S. K. and Schaubroek, J. (2000) Improving group decisions by better pooling information: A comprehensive advantage of group decision support systems, *Journal of Applied Psychology* 85, pp. 565–573.
Maher, M. L. (1999) Designing the virtual campus as a virtual world, Presented at 1999 Conference on Computer support for Collaborative Learning.
Nemeth, C., Mosier, K., and Chiles, C. (1992) When convergent thought improves performance: Majority vs. Minority influence, *Personality & Social Psychology Bulletin* 81, pp. 139–144.
Osborn, A. F. (1963) *Applied Imagination*, 2nd edn, Scribner, New York.
Sharon L. Greene (2002) Characteristics of applications that support creativity. Special issue on creativity IT tools, *Communications of the ACM*, 45 (10).
Singhal, S. and Zyda, M. (1999) *Networked Virtual Environments – Design and Implementation*, ACM Press Books, SIGGRAPH Series, 23 July 1999, ISBN 0-201-32557-8, 315 p.
Sternberg, R. (ed.) (1999) *Handbook of Creativity*, Cambridge University Press, Cambridge, UK.
Strasser, G., Kerr, N. L., and Davis, J. H. (1989) Influence Processes and Consensus Models in Decision-Making Groups, in P. Paulus (ed.), *Psychology of Group Influence*, 2nd edn, Erlbaum, Hillsdale, NJ, pp. 279–326.
Stroebe, W. and Diehl, M. (1994) Why Groups Are Less Effective Than Their Members: On Productivity Loses in Idea-Generating Groups, in W. Stroebe and M. Hewstone (eds.), *European Review of Social Psychology*, Vol. 5, Wiley, London, pp. 271–303.
Support Tools (2005) Workshop Sponsored by the National Science Foundation, June 13–14, 2005, Washington DC. http://www.cs.umd.edu/hcil/CST/
Yellowlees, P. M. and J. N. Cook (2006) Education about hallucinations using an internet virtual reality system: a qualitative survey, *Academic Psychiatry* 30, pp. 534–539.
Zyda, M. (2007) Creating a science of games, *Communications of the ACM*, 50 (7), pp. 27–29.