Research Statement

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Background

There is growing interest in technology that promotes creativity. The availability of such technology is attractive to creative talents, and such talent is needed to build competitive businesses and competitive national economies.[1] Technology that promotes creative thinking in schools is also a focus of many nations' research programs. Some even argue that better creative tools are necessary if humanity is to meet the challenges of the 21st century.

My research focuses on tools that help users enter and sustain a state of creative flow.[2] This is a well studied psychological state that can be detected with standard instruments. Flow experiences have nine key attributes[3]:

1. ***Intrinsic enjoyment***
2. ***Challenge level balance***
3. Automatic actions
4. Goal clarity
5. ***Immediate feedback***
6. ***High concentration***
7. ***Sense of personal control***
8. Loss of self-consciousness
9. Distorted sense of time

I believe creative tools are most helpful in promoting the five flow attributes highlighted above. Creative tools can help to balance the level of challenge for users by assisting users through their learning process. Creative tools can provide immediate feedback by helping users to quickly evaluate hypotheses as they solve problems. They can promote high concentration by removing distractions and helping users discover connections. They can give a sense of personal control by allowing users to express ideas with rich, multi-channel input. Finally, creative tools can increase the intrinsic enjoyment of tasks both by providing a fun or aesthetically pleasing experience and by helping users achieve higher-quality results.

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[1] Florida, R. *The Flight of the Creative Class.* New York: HarperCollins (2005).
[2] Csikszentmihalyi, M. *Creativity: Flow and the Psychology of Discovery and Invention.* New York: HarperCollins (1996).
[3] See Carr A, *Positive Psychology: The Science of Happiness and Human Strengths* (2nd edition). London, Routledge (2011), 113.

Most creative tool researchers agree that multidimensional in-depth longitudinal case studies are necessary to thoroughly evaluate creativity support tools[4]. That is why I focus my efforts on developing robust tools that can be deployed into the field and observed under normal working conditions. The following pages give a brief overview of tools I have developed and how they help users enter a state of creative flow.

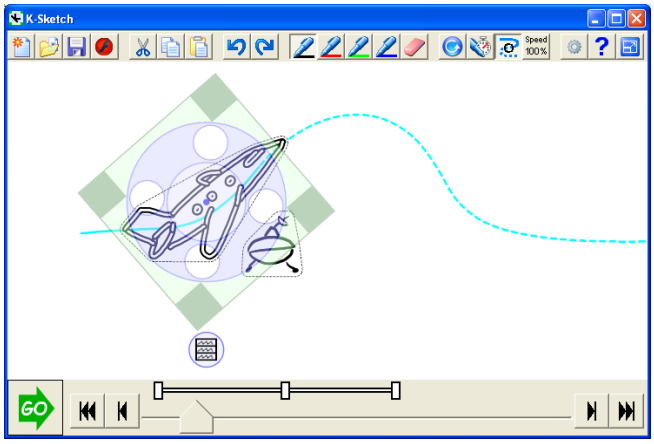
Research Areas

Informal Design Tools

Informal interfaces help designers avoid focusing on precise design details by capturing ideas in rough form. Current creative tools focus too much attention on presentation details, which can break designers' concentration and prevent them from achieving a state of creative flow. The use of rough input such as sketches and speech helps designers achieve a flow state, because they can concentrate more on their task and have a greater sense of personal control. In situations where precision is needed, informal tools can help designers perform rapid iteration on their ideas, which is the surest path to a high quality result.

K-Sketch

K-Sketch is a "kinetic" sketch pad for informal animation [1]. More and more people want to create and share animation, but current animation tools are either too restrictive or too complex. K-Sketch helps balance the level of challenge for novice users by giving them a gradual learning curve that makes it easier to create longer, more complex, or more polished works. By animating sketched objects with real-time demonstration, users can get an even greater sense of personal control and enter a flow state more quickly.



K-Sketch promotes creative flow with a gradual learning path that balances the challenge for novice animators. Sketching and demonstrated movement also gives them a greater sense of personal control.

Task analysis and user interface modeling were essential to K-Sketch's success. The design process began with field studies that gathered 72 usage scenarios for the tool. Then, conceptual modeling identified 18 possible animation operations, of which 10 were chosen through a process called interface optimization (described later). Only five simple operations are needed to complete about half

[4] Ben Shneiderman et al. Creativity Support Tools: Report From a U.S. National Science Foundation Sponsored Workshop. *International Journal of Human–Computer Interaction*, 20,2 (2006), 61–77.

of the usage scenarios, which helps new users get started quickly and gradually learn more as needed.

K-Sketch has proven its value in laboratory studies and field studies [1]. One laboratory study observed 16 novice animators performing two tasks with K-Sketch and Microsoft PowerPoint. K-Sketch allowed participants to work three times faster and required half the practice time. It also felt significantly faster and easier and imposed much less cognitive load. Similar benefits were seen in another laboratory study that compared K-Sketch to a key frame-based animation tool (The TAB Lite). This study also showed that K-Sketch users needed to do less preparation and less mathematical computation. In field studies, K-Sketch was used effectively by a user interface designer prototyping animated feedback for a new interaction technique. It was also used by over one hundred high school science students performing learning exercises.

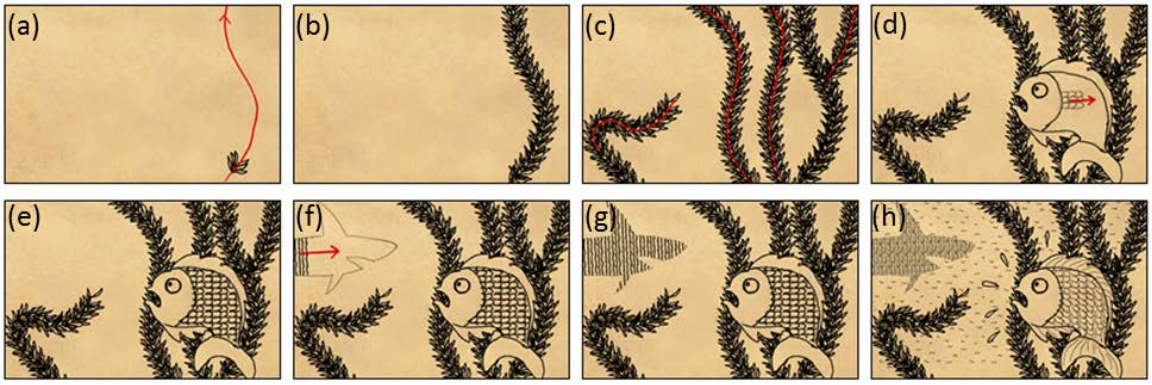
I am currently working on a new version of K-Sketch that is more robust and deployable via the web to many platforms. To make K-sketch more attractive to artists, this new version also provides a migration path from informal, real-time animation techniques to more formal, key frame animation techniques. I am also collaborating with education researchers to deploy K-Sketch in schools where I can carefully observe its effects on student learning and engagement.

PlaySketch

Storyboards are a common tool for fleshing out aspects of a video game design early in the design process. With a series of quick sketches, a storyboard can effectively communicate a sequence of events to other members of a design team. Thus, storyboards give designers a high sense of personal control and immediate feedback, which helps them to enter a state of creative flow.

Storyboards are a powerful tool, but they have two significant limitations. First, they are static, and they cannot effectively communicate many design details for a dynamic video game. This limitation prompts many designers to create animatics, which are storyboard frames presented with a sound track and some simple animation. Animatics communicate ideas effectively, but they can take hours to produce, breaking the designer's creative flow. The second limitation of storyboards is that time always advances in a straight line, while action in a video game can branch depending on a player's actions. These limitations can cause storyboards to be misinterpreted by a design team.

I am developing *PlaySketch*, which will allow video game designers to create animated storyboards with branching timelines while still preserving the sense of creative flow they get from traditional storyboards. This will give professional game designers a powerful new way to get ideas out of their heads quickly and into a group's consciousness where ideas can be refined.



Using Vignette to create a pen-and-ink illustration. (a) Draw leaf strokes (black) and gesture (red). (b) Texture created from gesture and strokes. (c) More textures. (d) Draw scale strokes and gesture. (e) Region filed with scales. (f) Draw hatching strokes and gesture. (g) Fill region with hatching. (h) Final illustration created in minutes.

Other Informal Design Tools

I am continually in search of opportunities to build effective informal design tools. *Vignette* is an interactive system that facilitates texture creation in pen-and-ink illustrations [4]. Illustrators draw a fraction of a texture and use gestures to automatically fill regions with that texture. Vignette gives illustrators a greater sense of personal control than existing texture generation systems, because Vignette preserves their existing workflow and style. Vignette also promotes high concentration, because there is no need for a complex and distracting array of controls. Finally, the preservation of personal style can make the illustration process more intrinsically rewarding. All of these factors make it easier to achieve creative flow.

SandCanvas is a tabletop system that allows artists to create compelling visual performance art in the style of sand animation [3]. SandCanvas facilitates flow primarily by providing a high sense of personal control. Designers interact with simulated sand through the entire region of contact their hand makes with the surface, not just touch points. Designers can record these gestures and play them back during performances for an even greater sense of personal control. SandCanvas's simple interface also promotes high concentration, and the

SandCanvas allows artists to create compelling visual performance art in the style of sand animation. (left) Using the entire region of contact gives artists a greater sense of personal control. (right) Animations created with SandCanvas.

process of pushing around sand to make beautiful images is intrinsically rewarding.

User Interface Design Tools

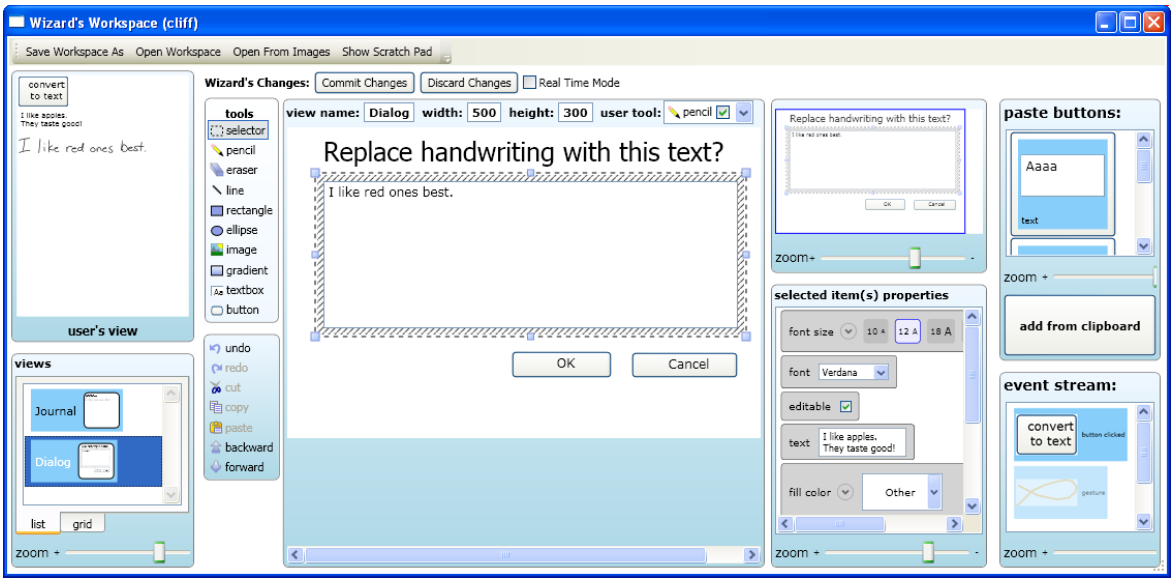
The creative tools we build are largely determined by the tools we use to build them. For this reason, I am constantly seeking to develop tools that help people design and build systems that promote creative flow.

Wizard of Oz Prototyping

Informal interfaces are difficult to design, because few conventions have evolved. When should free-form input be captured? What devices should be used? How will input be interpreted? Will input be recognized automatically? What if recognition fails? Every concrete design must attempt to answer these questions, but designers need to check their assumptions against actual user behavior to validate their assumptions. Prototyping is a general technique for handling such situations.

A wizard of oz prototype allows a designer to collect feedback on an interface that appears complete, even though it is being operated by someone "behind a curtain." My investigation of wizard of oz prototyping began with SketchWizard, a tool that allows designers to simulate real-time responses to sketched input using graphical editing commands [2]. Evaluations of SketchWizard showed that most users do not realize a human being is manipulating these prototypes, even when a designer needs half a minute to prepare responses to users' input.

I plan to extend SketchWizard to support more input styles and gesture recognizers so designers can simulate interfaces that give users a greater sense of personal control. Designers will also be able to interpret sketched user input



The SketchWizard "Wizard's Workspace" allows a designer to simulate a user interface in real time using graphical editing commands. In the center, a designer is preparing a dialog box that will be shown to a user during a test. The user's current view is in the upper left.

with recognition engines and generate automated responses with simple designer-created macros. This will allow designers to simulate interfaces that give more immediate feedback. Finally, I will allow Wizard of Oz tests to coordinate the activities of multiple devices and multiple users, which will allow designers to simulate a wider variety of systems.

Interface Optimization

Balancing the challenge level in creative tools is important for promoting flow. Designers can achieve this by considering three conflicting constraints: speed, complexity, and versatility. The system must allow users to accomplish tasks quickly, but it should avoid making high cognitive demands. Further, it is difficult to meet both of these constraints while supporting a wide variety of tasks. Interface optimization is a collection of user interface modeling tools and techniques that help designers balance conflicting speed, complexity, and versatility constraints.

Interface optimization was pioneered during the K-Sketch project [1] and expanded for the PlaySketch project. The process begins with a collection of usage scenarios for an interface. Scenarios are analyzed to find points in the design space, and these designs are evaluated against the original set of scenarios to determine their speed (average time to complete), complexity (number of controls), and versatility (number of scenarios supported). When the analysis is complete, designers have a way to quantify the relative speed, complexity, and versatility of different points in the design space. Visualizations of these design tradeoffs can help designers choose a set of controls that are balanced appropriately for their users. Designers can also plan a learning path that takes users gradually from basic understanding to an advanced understanding of an interface.

Moving from Informal to Formal

In the future, I plan to explore creative tools that allow users to move designs gradually from an informal state to a formal state. Conceptually, the process of taking a design from an informal state to a formal state is a gradual process. However, an artificial wall currently exists between users' rough sketches and the finished artifacts produced from them. Taking the first step into a formal representation requires users to interrupt their creative process and coerce their rough designs into a formal representation. This destroys the concentration and sense of personal control that is so important for maintaining a state of flow.

Consider the following scenario: an animator makes character sketches in a notebook but then wishes to show her clients an animated storyboard. She scans one of her drawings and animates it in Adobe AfterEffects. She also finds an image with a pleasing texture for clothing, and she adds this to the character's shirt. After showing the character to her client, she wants to browse the animated character design alongside her other character designs, but the two exist in different worlds. She also wants to transfer the clothing texture to all the other

sketches of the same character, but she will not be able to do this until these other sketches are brought into AfterEffects.

K-Sketch and PlaySketch blur the boundary between rough sketches and the animations produced from them. The next step is to enable designers to add precise details when they are needed. This will make it possible to move seamlessly between sketching character ideas, working out their motions, and refining their appearance without losing a sense of creative flow. I plan to expand this into an electronic notebook that helps users managing rough notes or sketches and move them gradually to and from a variety of more polished forms, such as animations, presentations, and web sites.

Selected Publications and Outputs

1 Davis RC, Colwell B, Landay JA. K-Sketch: a “kinetic” sketch pad for novice animators. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pp 413-22. Florence, Italy, April 2008.

2 Davis RC, Saponas TS, Shilman M, Landay JA. SketchWizard: Wizard of Oz prototyping of pen-based user interfaces. *Proceedings of the ACM Symposium on User Interface Software and Technology*, pp 119-28. Newport, RI 2007.

3 Kazi RH, Chua K-C, Zhao S, Davis RC, Low K-L. SandCanvas: A Multi-touch Art Medium Inspired by Sand Animation. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pp 1283-92. Vancouver, Canada, May 2011.

4 Kazi RH, Igarashi T, Zhao S, Davis RC. Vignette: Interactive Texture Design and Manipulation with Freeform Gestures for Pen-and-Ink Illustration. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* Austin, TX, USA, May 2012.