Improving Interaction Models for Generating and Managing Alternative Ideas during Early Design Work

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ABSTRACT

A principle of early design work is to generate and manage multiple ideas, as this fosters creative insight. As computer tools are being increasingly used for early design work, it is critical to understand how their interaction models affect idea management. This paper reports results of a user study comparing how the use of three interaction models – tab interfaces, layered canvases, and spatial maps – affects working with multiple ideas. Designers (N=18) created and managed ideas for realistic design tasks using each model. We observed strategies for creating and managing ideas, measured process outcomes and tool interactions, and gained extensive participant feedback. From the results, we derive new lessons that can be broadly applied to improve how interfaces support multiple ideas and implemented the lessons within one model to demonstrate their efficacy.

KEYWORDS: Creativity, Design, Multiple Ideas, Reflection.

INDEX TERMS: H.5.2 [Information Interfaces and Presentation]: Interfaces - Evaluation/methodology; D.2.2 [Software Engineering]: Design Tools and Techniques – User interfaces

1 INTRODUCTION

A principle of early design work is to generate and manage multiple ideas [15]. An idea typically represents a direction for addressing a design problem and often takes the form of a rough sketch or visual mockup [1]. Working with multiple ideas fosters understanding of the design problem [4], re-interpretation of ideas [5, 18], and reflection-on-action [17]; all of which can lead to higher quality outcomes [10, 12].

Designers have typically used physical tools for conceptual design work but are increasingly utilizing computer tools in domains such as graphic, web, and product design. Better support for interactive sketching [7], simulation [1] and collaboration [6], among other factors, are helping to drive this shift. As this trend continues, it is important to assess and improve how the interaction models of tools affect design work such as generating and managing multiple ideas.

Creating and managing ideas within computer-based design tools can be mapped to many types of interaction models. One common model offers the use of tabs where each new idea can be placed in a separate page indexed by a distinct tab. MS OneNote, FrontPage and Visio embody this model. Tabs provide well-organized access to specific ideas, but a designer cannot view all of the ideas at once for reflection or a subset of the ideas for side-by-side comparison [19].

Another popular model is the use of layered canvases where each new idea can be placed into a distinct layer or canvas. Tools such as Photoshop, GIMP, and digital sketching tools (e.g., [7]) embody this model. Users can arrange, group, and toggle the visibility of layers to compare, view, and edit ideas. However, as ideas come quickly in and out of favor, it is difficult to capture the ongoing design situation [22]. As with tabs, it is also difficult to view all the ideas at once.

To overcome these limitations, researchers have studied how designers manage ideas with physical tools and offered the model of interactive spatial maps [8]. TEAM STORM [8] and other tools [14] embody this model. In this model, ideas are represented as thumbnails in the map, thumbnails can be positioned and scaled to capture the design situation (e.g., the favour of ideas), and all ideas can be seen at once to support reflection.

Though many models exist, few studies have compared how they affect idea management. This paper takes a first step by reporting results from a user study comparing how three interaction models – tab interfaces (OneNote), layered canvases (Photoshop), and spatial maps (TEAM STORM) – affect the generation and management of multiple ideas in design activity.

In the study, designers (N=18) created and managed ideas for realistic design tasks using each model. Ideas were created as rough concept sketches. We observed designers’ strategies for managing ideas, measured process outcomes (e.g., number of ideas generated) and tool interactions (e.g., number of reflective acts), and gained extensive participant feedback.

Our results make three contributions. First, from an analysis of how participants interacted with each model tested as well as participant feedback, we derive new lessons that can be applied to improve how interaction models of existing tools support multiple ideas. We also demonstrate the feasibility and efficacy of the lessons by implementing them within one model. Second, we found that working with multiple ideas is a non-linear process, e.g., working on one idea spurs thought for other ideas while other ideas may be reviewed to spur thought for the current one. Last, our results show the spatial map better supports reflection, a key aspect of design [17], while all models performed similarly on the other measures. This indicates that spatial maps offer a viable design alternative to the other models tested and designers can quickly adapt to the model given.

2 RELATED WORK

We discuss the interaction models and strategies for managing ideas in computer tools and evaluations of related techniques.

2.1 Interactions and Strategies for Managing Ideas

Existing design, productivity, and programming tools offer different interaction models to support multiple ideas. One model offers a tab interface (e.g., OneNote, Visio, and FrontPage) where an idea is placed on a distinct page and is accessed by a tab.
Another model offers a layered canvas (e.g., Photoshop and [7]) on which ideas can be stacked. The main limitations of these models are that the user either cannot see all of the ideas at once or cannot organize them in a way that captures the ongoing design situation [8]. These issues hinder reflection-on-action, re-interpretation of ideas, and the generation of new ideas [2].

Independent of a specific tool, a common user strategy for working with multiple ideas is to save successive copies of an idea with similar names (v1.psd, v2.psd, etc.) [19]. But the benefits of multiple ideas cannot be fully realized since the ideas are not immediately visible or accessible unless opened in a tool, e.g., using multiple canvases or layers.

The limitations of existing models and user strategies have inspired researchers to develop new interaction models for managing multiple ideas. For example, in TEAM STORM, researchers demonstrated the use of interactive spatial maps for managing ideas [8]. All ideas or a subset can be easily viewed together and representations can be positioned and scaled to support re-interpretation and reflection. The model was derived from observations of how designers generate and manage design ideas using paper artifacts. Spatial maps have also been used for the construction of narratives [14].

Parallel Pies embeds multiple variations of an image within the same workspace to facilitate side-by-side comparisons. Variations are represented as thumbnails in the workspace and contain identifying symbols [20]. Juxtapose is a system for exploring multiple variations of functional prototypes in parallel [9]. It provides methods for rapidly exploring design alternatives of the underlying programming code and runtime parameters. Inspired by architectural practice, Wong proposes the use of transparent layers to reveal the current sketch in relation to prior ideas [21].

Though many interaction models exist, there have been few empirical studies comparing how different models affect idea management. Our work represents one of the first such studies by comparing the use of tabs, layered canvases, and spatial maps for creating and managing multiple ideas.

2.2 Evaluations of Techniques for Managing Ideas

For brainstorming, researchers have compared how a group interacts with an evolving set of shared ideas [16]. They found that the ability to structure ideas fosters the creative process. Our work differs by comparing multiple models for structuring ideas, studying visual design tasks, and probing effects on design activity rather than only group dynamics.

Coughlan and Johnson studied how ideas occur in creative work and strategies and tools used to represent and refine them [3]. A suggestion they make for idea development is that the creative environment must support the review of multiple idea representations and captures at the same time.

Several studies have compared how the use of different tool modalities (paper vs. computer) affects design activity [1, 2, 11]. For example, Black compared how the use of a graphic design tool affects the design process and outcomes relative to the use of pen and paper for conceptual design [2]. One important lesson reported in that study was that design tools must better support working with multiple ideas in parallel.

A subjunctive interface supports the parallel setup, viewing, and control of alternative scenarios [13]. When compared to a traditional browser for information access tasks, empirical studies show that users of a subjunctive interface are able to complete tasks faster and with greater satisfaction [13].

Relative to this corpus of evaluative work, our research is original in that we compare how three common interaction models affect working with multiple ideas in design activity.

3 Comparative Study

Our study was designed to answer three main questions:

- How does the interaction model of a design tool affect how a designer generates and manages multiple ideas?
- What are the strengths and weaknesses of using different interaction models for working with multiple ideas from a designer’s perspective?
- What lessons can be learned for improving the design of interaction models for generating and managing ideas?

3.1 Experimental Design

The study employed a partially balanced incomplete block design in which the participant served as the blocking factor and treatments consisted of pairing each model (spatial map, tab interface, and layered canvas) with each task (watch, logo, and bookmarking site). A participant used each of the three models (tools) and completed each of the three design tasks. Every model/task combination and the order in which they were completed were utilized in the study and assigned an equal number of times. Our use of a within-subjects design allowed the participants to compare and contrast the different models based on direct experience.

3.2 Participants

Eighteen participants (nine female) participated in the study. There were four undergraduate and eight graduate students from local institutions and six professional designers from the local area. All participants had at least one year of prior design experience and at least one year of prior experience using a computer-based design tool. Each participant was remunerated $60 for participating. An additional incentive ($30) was offered to the person who received the highest design score using each tool. This was computed as an average of the number of ideas produced and the perceived quality of the final outcome as judged by two independent experts.

3.3 Interaction Models

Three interaction models were compared in the study:

- Spatial maps. TEAM STORM (TS) was used to represent the class of tools that offer spatial maps for managing ideas (e.g., Visio, FrontPage, and [9]). As shown in Figure 1(a), each idea (i.e., a sketch) corresponds to a thumbnail representation in the map. When a new idea is created, a corresponding thumbnail appears in the map. Thumbnails can be scaled and positioned as desired to capture the ongoing design situation (e.g., as designs come in favor, they can be positioned near the center and/or scaled larger). Selecting a thumbnail makes that idea current in the sketch editor.
- Tabs. Microsoft® Office OneNote® 2007 (ON) was used to represent the large class of interfaces that offer tabs for managing ideas (e.g., Visio, FrontPage, and [9]). As shown in Figure 1(b), OneNote is a flexible digital notebook that allows users to create and aggregate many types of information on a page. In OneNote, one page is shown at a time, a tab is associated with each page, and a user switches pages by selecting the desired tab.
• Layers and canvases. Adobe® Photoshop® CS3 (PS) was used to represent the class of interfaces offering canvases and layers for managing ideas (e.g., GIMP and [7, 20, 21]). Shown in Figure 1(c), Photoshop allows a user to explore ideas either by creating multiple layers on a single canvas or by creating multiple canvases. Layers can be used to modify parts of a canvas independently.

These models of interaction were selected because of their different styles for managing ideas and because the models either are already commonly used in or have been proposed for conceptual design tools. Our goal was not necessarily to prove one model superior but to understand their relative merits and limitations. The specific tools were selected as they arguably implement the respective models as well as any other tools available and/or were reported by designers in a pilot study as a commonly used tool for early design.

3.4 Design Tasks

Three design tasks were developed for the study:

• **Design a new watch for the twenty-first century.** Participants were asked to develop new ideas for a watch intended for those who are replacing their watches with cell phones and other digital devices to tell time. They were asked to develop the watch especially for the teenage demographic or for those simply in the market for an inexpensive (< $100 US) watch.

• **Design a new logo and slogan.** Participants were asked to come up with ideas for a new logo and slogan for a popular fast food chain that was developed through the acquisition of Chipotle Mexican Grill® by McDonald’s®. Participants were asked to especially target those who would appreciate the use of healthier, more natural ingredients than those typically found on a McDonald’s menu.

• **Design a new interface for a social bookmarking site.** Participants were asked to develop ways to make a popular social bookmarking website more exciting and engaging. The design should please those participants who are already utilizing the site to manage a large number of bookmarks.

We encouraged participants to generate as many ideas as possible in the allotted time and, at the end of each session, participants were asked to choose the idea that they liked best. Ideas were created as rough concept sketches in the respective tool and participants were asked to convey the overall direction but not worry about details. Participants were informed that the assessment for the additional incentive included the number of ideas generated. Design tasks were performed on a Tablet PC running the necessary software. Sketching was performed via stylus input while text could be entered via the keyboard. Participants were also allowed to browse the Web for examples and design inspiration as much as desired.

These tasks are representative of three domains - industrial design (watch), graphic design (logo) and interaction design (bookmarking site). Results from a pilot study confirmed that the design tasks were perceived as being similar in difficulty and representative of those in design practice. Though these tasks are less complex than tasks typically faced in practice, they enabled a snapshot of authentic design activity sufficient for our study.

3.5 Procedure

Before the participants began the experiment, we went through an informed consent process. Participants were asked to take part in three sessions in which they would use a Tablet PC to complete a different design task. Each of these tasks was carried out using a different design tool. All sessions lasted approximately one hour on each of three consecutive days.

The first task was e-mailed to the participant the day before the first session so she could begin thinking about ideas. Once at the lab, the participant was given a brief tutorial on the assigned tool and allowed to practice. Any questions about the task or tool were answered and the participant worked on the task for forty minutes. The participant then selected the design that she felt best solved the task, categorized her ideas, completed a questionnaire about generating and managing ideas with the tool, and discussed with the experimenter her experience with the tool. The next two sessions proceeded in a similar manner. This was followed by the exit questionnaire in which the participant ranked the tools along several dimensions and described their relative merits and limitations. Finally, the participant discussed her overall experience using the three tools for creating and managing ideas. The participant’s screen interaction was recorded using screen capture software.

3.6 Measurements

For each design task, the following data were collected:

• **Strategies for working with multiple ideas.** We observed the participant’s strategies for generating, switching, and organizing design ideas. These data were collected by viewing the screen recordings and by asking the participant to describe the strategy she employed after the session.
• **Process outcomes.** This consisted of two measures: the number of ideas generated and number of idea categories. For example, for TS, the number of ideas was the number of representations in the workspace. For ON, it was the number of pages created or the number of distinct areas within a page. For PS, it was the number of canvases and layer variations. The number of idea categories was determined by asking the participant to retrospectively organize her final set of ideas into categories as best as possible and counting the result.

• **Tool interactions.** The measures were the number of idea switches, reflective acts, and organizational interactions. An idea switch was moving away from the current idea to a different idea or creating a new one. A reflective act was defined as an interaction(s) causing two or more ideas to be seen in rapid succession, e.g., selecting two or more thumbnails in TS, tabs in ON, or layers or canvases in PS. During a reflective act, a participant typically viewed each idea for only a few seconds. Organizational interactions were those made to arrange ideas as desired. For example, in TS, actions include positioning and scaling thumbnails and resizing the workspace. For ON, actions included zooming, reordering tabs, and grouping tabs. In PS, actions included manipulating the canvases and layers. These measures were determined from the screen recordings.

• **Participant feedback.** After a task, participants rated their agreement with neutral statements concerning the tool’s facilitation of generating ideas, creating diverse ideas, managing and classifying ideas, capturing the design situation, viewing ideas, reflecting on ideas, and overall creative process. Ratings were structured using a 5-point Likert scale (1=strongly disagree; 5=strongly agree). There were also two open-ended questions about the strengths and weaknesses of the tool. After the study, participants completed another questionnaire in which they ranked the tools according to the same criteria in the session questionnaire and were asked for additional thoughts on the tools’ relative strengths and weaknesses. Rankings were given as 1=Best; 3=Worst, but tools could be ranked the same.

4 Results

In this section, we first discuss the observed strategies for working with multiple ideas and qualitative feedback. We then report quantitative results for the process measures and tool interactions and the participant ratings and rankings. Overall, we were very impressed by the quality of ideas generated and the careful process followed by participants. Even though the allotted time was short, all participants generated multiple ideas (μ=8) in multiple categories (μ=4). Ideas were thoughtful, creative, and task relevant. Feedback in the questionnaires and discussions was in-depth and informative. Participants were clearly engaged in the design tasks.

We note one caveat of the study. At the start of the study, TS provided only a single brush color and size, and participants were overly focused on these limitations in the questionnaires and discussions. To address this issue, after nine participants completed the study, we modified the tool to support more brush colors and sizes and allow text entry. The last nine participants used this minor revision of the tool. Analysis of the data before and after the modification to TS showed no significant differences between the dependent variables, so here we report the results without separating the analysis into two parts.

4.1 Observed Strategies and Qualitative Feedback

As might be expected, participants adapted their working style based on the affordances of the model (e.g., manipulated thumbnails in TS, tabs in ON and layers in PS). However, one common behavioral pattern did emerge. The creation and evolution of multiple ideas was almost always non-linear. For example, after externalizing her thoughts into the current idea for some time (e.g., a few minutes), the participant would suspend the activity; flip through, re-arrange, briefly edit, or rename existing ideas; then either resume editing the suspended idea or switch to another; and repeat. This pattern was fairly consistent across participants, tasks, and tools; though the time between cycles varied. Table 1 shows that participants switched ideas about 26 times per task.

This behavior likely occurred because either new thought was emerging for other ideas while working on the current idea or the participant wanted to view the other ideas as a means for sparking new thought on the current idea. As one participant aptly explained “multiple ideas do not happen all at once; or whenever the user wants it to.” Another participant stated “ideas are always running and competing against each other,” while a third participant noted “once one [idea] starts flowing, the ideas seem to multiply.” Some participants exhibited more structure in their actions. For example, one participant said, “after every design, I would glance at what was done already, revisit some concepts or identify some design gaps.”

Overall, this behavior confirms that working with multiple ideas is typically a non-linear and emergent process. It is intrinsic to early design activity, and it is therefore critical for user interfaces of design and problem solving tools to efficiently support it. This behavior is similar to Schon’s concept of reflection-in-action [17], but our work shows that this reflective behavior manifests across multiple ideas.

4.1.1 TEAM STORM (TS)

As shown in Figure 2, with TS, participants worked with design ideas by positioning and scaling corresponding thumbnails on an interactive 2D spatial map. Participants created a new canvas either to represent a new design direction (i.e., a new idea) or to explore different aspects of one idea (e.g., how the bookmarking site changes in response to user interaction). Participants scaled and positioned ideas to create conceptually similar groups or to capture the temporal order in which the ideas were created.

Participants overwhelmingly agreed that the use of 2D maps was effective for working with multiple ideas. The strengths were being able to see all ideas at once for reflection and the ability to spatially group ideas into themes. One participant stated this.
allowed him to “compare and contrast previous ideas,” another stated that this gave a sense of “where they were in the process and where they wanted to go,” while a third participant appreciated the “retrospective vision of ideas.” Finally, one participant expressed “all three tools would benefit from having 2D spatial maps.” Nearly all participants expressed similar positive comments about this aspect of the tool.

Participants also noted several weaknesses. One was the small size of the thumbnails. For example, this made it difficult to identify specific ideas as many looked similar at this scale. As one participant said “searching among old images was tough” and felt limited by the number of canvases they could fit comfortably in the workspace. A related weakness was the inability to label groups of ideas. Participants expressed that scale and position helped, but wanted to add labels to remember the represented theme. As one participant said, “I had to page through previous designs because of the lack of labelling.” A third weakness was that one canvas could obscure others in the spatial map and participants were concerned about “losing ideas.” Finally, participants wanted to be able to easily copy content between thumbnails to foster idea generation.

There was also some unexpected behavior. For example, the expected technique for switching between ideas was to select the desired thumbnail within the workspace window. Most participants followed this approach. But some maximized the desired thumbnail within the workspace window. Most expected technique for switching between ideas was to select the thumbnails to foster idea generation.

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than ON (µ=.11, sd=.47; p=.018) and Task did not have any main effects or interact with Model. We report quantitative results from our study. Analysis showed that participants were more organizational interactions performed with PS interactions (F(2, 32)=5.09; p=.01). Post hoc analysis showed that Model had a main effect on the number of organizational interactions and tool interactions. A repeated measures ANOVA showed that participants were focused mostly on generating and thus will not be discussed further.

4.2 Quantitative Results
We report quantitative results from our study. Analysis showed that Task did not have any main effects or interact with Model, and thus will not be discussed further.

4.2.1 Process Measures and Tool Interactions
The left five columns of Table 1 show the data for process measures and tool interactions. A repeated measures ANOVA showed Model had a main effect on the number of organizational interactions (F(2, 32)=5.09; p=.01). Post hoc analysis showed more organizational interactions were performed with PS (µ=13.78, sd=22.72) than with ON (µ=.11, sd=.47; p=.018) and more were performed with TS (µ=11.83, sd=7.46) than ON (p=.05). There was no difference between PS and TS.

An ANOVA showed that Model had a main effect on the number of reflective acts (F(2, 32)=11.58; p<.001). More reflective acts were initiated in TS (µ=9.67, sd=9.16) than in ON (µ=2.33, sd=2.74; p<.001) and more were initiated in TS than in PS (µ=1.83, sd=1.82; p<.001).

There were no statistical differences in the number of ideas generated, number of idea categories created, or number of idea switches. Table 1 summarizes these results.

4.2.2 Participant Ratings and Rankings
The right eight columns of Table 1 summarize participant ratings. An ANOVA showed that the Model used affected participants’ ratings of how well they were able to reflect on ideas (F(2, 32)=3.88; p=.031). Participants felt they were able to better reflect on their ideas when using TS (µ=4.28, sd=83) than when using ON (µ=3.5 sd=1.15; p=.04). Interestingly, Model did not affect ratings for ‘capturing the design situation’ (i.e., how well one’s opinion of ideas is captured in the tool itself). This is likely due to the fact that participants were focused mostly on generating and managing ideas during the study rather than evaluating them.

Table 2 summarizes participant rankings of the tools (made at the end of the experiment). A Friedman test showed that Model affected participants’ retrospective rankings for how well they were able to reflect on the set of ideas, (χ² (2, N=18)=10.78, p=.005). Follow-up pair-wise comparisons were conducted using a Wilcoxon test and the ranking for TS was better than ON (p=.24) and PS (p=.008). There was no difference between PS and ON.

A similar test showed that Model affected participants’ rankings for being able to view the entire set of ideas (χ² (2, N=18)=11.91, p=.003). Pair-wise comparisons showed that TS was ranked higher than ON (p=.031) and PS (p=.005). There were no other differences.

The ratings and rankings reinforce prior results. The spatial map enabled reflection on and viewing of the set of ideas better than the other models. However, it is also important to point out that although reflection is widely regarded as an intrinsic and central part of the design process [17], how it directly relates to creative output remains unknown.

5 Discussion
A central goal of this study was to understand how different interaction models affect how designers create and manage multiple ideas during early design. The three models tested performed similarly on most measures, but the spatial map better facilitated reflection, i.e., more reflective acts were performed, and it was rated and ranked higher on this dimension. This difference may be attributed to the ability to more easily view all ideas at once or capture the design situation with the spatial map. Overall, the results show that the use of spatial maps offers a viable alternative to the use of layers or tab interfaces when creating new or revising existing models in computer tools for managing ideas.

One reason that further differences were not found could be due to the short duration of the tasks used in our study. In practice, design problems will persist for weeks or months and many more ideas would be generated and evaluated as part of a broader design process. For example, one participant chose not to review ideas for fear of “stifling new ways of thinking” but noted he would do this later in the process. Another plausible reason is that designers are simply able to adapt to different styles of interaction without it affecting their process. Further research with longer duration tasks and in the field is needed to better assess these possibilities.

Because the models performed similarly overall, we believe it is most prudent to consider how existing models can be improved rather than try to argue for any specific one. From the results and participant feedback, we have therefore derived new lessons that can be generally applied to improve the class of interaction models for working with multiple ideas.

L1. Make it really easy to switch between ideas.
Most participants switched ideas frequently during the tasks. For example, on average, there were about 26 switches among eight ideas for each task. Reasons for switching included that while working on one idea, new thought would emerge for others, participants wanted to review existing ideas to spawn new design directions, or participants wanted to copy and paste content between the ideas. For example, one participant stated that efficient idea switching is needed “to get the ideas out as they
were flowing ... without disturbing the flow of the rest of the work.” Another participant argued that “the experience of creativity entails having to juggle multiple ideas.” Participants sometimes struggled to identify the desired idea in the spatial map, layer in PS, or tab in ON. Methods that require less overhead and combine pictorial representations with descriptive labels could improve the efficiency of idea switching.

L2. Provide an efficient way to view multiple ideas at once.

The ability to view multiple ideas at once was desired by almost all participants. One participant stated that “I often needed to review my old ideas as a basis for new ideas” while another stated that seeing all ideas “allowed for boundaries and limitations to be exposed.” ON and PS particularly fell short here. For example, when using ON, participants had to quickly flip through the tabs as a way to review their ideas. This was done most often when a participant was trying to generate a new idea, compare ideas, or make similar edits across ideas (e.g., to change the color of the Chipotle pepper from green to red in all sketches). PS participants exhibited analogous behavior with layers. The models could be improved, for example, by generating a summary page that juxtaposes all or a subset of the ideas.

L3. Allow users to adapt the interface to their preferences.

Most participants liked having all their ideas persistently visible in TS, but some did not. These participants still wanted this information but wanted to access it at their preference. With PS, one participant expressed that the tool allowed them to view multiple ideas at once, but they “wanted to see multiple designs quickly – rather than after painstakingly arranging/zooming on the desktop.” Interfaces can therefore be improved by providing a method for toggling between the view of one idea and a comparison view of multiple ideas.

L4. Provide ways to identify ideas pictorially and textually.

ON displays the names of design ideas within the tabs while PS displays the names in the title bar of the canvases or in the layer panel. Ideas in TS are denoted by thumbnails in the spatial map. Preferences for textual or pictorial identifiers differed. For example, one participant wished that thumbnails of designs had been included with the labels in ON; whereas another participant wanted textual identifiers in TS; “I had to page through [the thumbnails] because of the lack of labeling.” Because of users’ different individual preferences and working styles, interfaces should allow users to choose the use of pictures, text, or both to help identify ideas.

L5. Provide multiple ways to group and classify ideas.

Regardless of the interaction model used, participants attempted to group and classify ideas as part of their creative process, which was also observed in [16]. For example, in TS, participants could “allowed me to efficiently move out of ideas, but without organization, it was harder to revisit them.” Several methods could be used to address this issue. For example, in ON, the tool could allow users to assign colors to tabs and automatically group tabs with similar colors. In TS, the tool could allow tags to be assigned to the thumbnails and allow the visibility of thumbnails to be toggled via tag selections.

L6. Provide an explicit means for capturing the situation.

Participants chose different ways to capture the design situation with the tools. For example, with TS, participants would scale a thumbnail or move it to a certain part of the workspace to indicate the idea was no longer focused. Another participant would “organize groups of canvases as little storyboard segments in the private workspace” so she could see how her ideas evolved over time. In ON, participants re-ordered tabs to put favored ideas at the top while others complained “there wasn’t a clear way to show which ones you liked best.” In PS, participants minimized canvases or toggled layer visibility when an idea went out of favor, but as one participant noted “there was no way to really rank things.” To address this in ON or PS, the tools could allow users to assign a value, symbol, or visual attribute to a tab or layer indicating the rank set of the idea (“ruled out,” “possible,” “best,” etc.). With spatial maps, users could color code the ideas to better differentiate their status.

L7. Support fluid composition and decomposition of ideas.

Participants typically managed ideas based on the model afforded by the tools, e.g., placing ideas into separate pages (tabs) in ON. However, as illustrated in Figure 3, a few participants preferred to create ideas on a continuous drawing surface. This method allows initial ideas to be created with minimal overhead, but does not scale well, e.g., it becomes more difficult to extend or arrange ideas or insert new ideas due to space conflicts. One solution that allows this working style yet may also scale better is to support composition and decomposition of ideas to and from a single work surface. For example, in ON or TS, the tools could allow a user to select multiple canvases and compose the idea content onto a new canvas with appropriate layout, and conversely, to split the content selected within a canvas into separate ones. PS already supports a similar function by allowing layers to be copied between canvases.

Table 2. Summary of participant rankings of the tools. Cells show the number of votes received. An asterisk (*) denotes a column in which statistical differences were found.

<table>
<thead>
<tr>
<th>Tool</th>
<th>Generate Ideas</th>
<th>Generate diverse ideas</th>
<th>Manage ideas efficiently</th>
<th>Classify ideas as desired</th>
<th>Capture design situation</th>
<th>Reflect on ideas*</th>
<th>View entire set of ideas*</th>
<th>Facilitate creative process</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEAM STORM</td>
<td>10</td>
<td>6</td>
<td>8</td>
<td>4</td>
<td>5</td>
<td>9</td>
<td>2</td>
<td>14</td>
<td>2</td>
</tr>
<tr>
<td>OneNote</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>7</td>
<td>8</td>
<td>6</td>
<td>4</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>Photoshop</td>
<td>3</td>
<td>8</td>
<td>7</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>3</td>
<td>8</td>
<td>7</td>
</tr>
</tbody>
</table>

5.1 Demonstrating the Lessons

We describe how our lessons were applied to improve the spatial map in TS. We chose this tool because its source code is available.

Our re-design is shown in Figure 5 and includes three main enhancements. One was to allow a user to assign tags to thumbnails and toggle the visibility of thumbnails with an assigned tag via the checkboxes. Tags are color-coded to facilitate visual connections with corresponding thumbnails. This technique...
addresses L1 because users can assign tags to help identify and switch between ideas and capture emergent attributes. L6 is addressed because users can assign tags indicating the favor of an idea and toggle the visibility of the more or less favored ideas. The technique directly supports L4 and L5.

The second enhancement is to support three distinct views of the idea space. These include a reflective view (spatial view offered now), temporal view (thumbnails are arranged in a matrix ordered by time of last modification), and favor view (matrix ordered by scale of thumbnails). Also, if the maximize button is selected on the workspace window, the thumbnails are also scaled to provide a detailed view. Users can switch between the views as desired without destruction (i.e., the reflective view is the same upon return from another view unless the user modified the size or position of a thumbnail). This addresses lessons L2 and L3.

The last enhancement enables efficient composition and decomposition of idea content, supporting L7. In the spatial map, a user can select multiple canvases and then select the composition operator from the tool palette at the bottom of the window. Content from the selected canvases are placed into a new canvas, all at the same scale and in a grid layout. The source canvases are then deleted. This feature is useful for grouping and managing incremental variations of a concept. For decomposition, a user can select content from a canvas, drag it to an empty area on the map workspace, and a new canvas is created with that content. This feature allows a designer to split off a variation and pursue it as a new design direction.

These lessons facilitated improvements to TS – improvements that would not have been known without the observations and results gained from our study. Though these lessons were demonstrated in TS, analogous improvements can be made for other models that support working with multiple ideas.

6 CONCLUSIONS

Working with multiple ideas is a staple of creative work. Many interaction models support the management of ideas, but empirical understanding is needed to carefully assess their relative merits and to produce principles for improving this critical aspect of interaction for conceptual design tools.

Our work has made several contributions to this area. First, we offered new lessons that can be broadly applied to improve how the interaction models of existing design tools support idea management. Second, we found that working with multiple ideas is a non-linear process, confirming the need for models to efficiently support multiple ideas. Last, our results showed the use of spatial maps offers a viable alternative for managing ideas as it performed similar to or better than the use of a tab interface and layered canvas.

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REFERENCES


