Analyzing Creative Processes: Qualitative Methods Meets Visual Analytics

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ABSTRACT

Creative processes are nuanced and dynamic. They differ from person to person, based on task and environment. It is important to characterize aspects of the creative process, the actions performed, as a way to gain insight about building better applications and pedagogy. Qualitative methods can help provide rich understanding of creative processes, but require as many as 10 hours of work to transcribe each video hour. Quantitative methods are fast, but often lack the same depth. This research proposes to enable and amplify bottom-up approaches from qualitative methods using techniques in a human-in-the-loop visual analytics system. By first better understanding creative processes, we can improve the design of applications that impact the quality of life of designers, analysts, and content creators.

1 INTRODUCTION

Creative and open-ended tasks dominate the schedule of designers, analysts, and others. For example, designers author graphics in Illustrator, analysts explore and manipulate in Tableau, and researchers curate and synthesize prior work. We use the term Creativity Support Environment (CSE) [24] to denote an application that seeks to extend human capabilities to explore, innovate, or author media. Prior tools use use interaction logs from applications to quantify the speed of one interaction following another [8], synchronize video with action types on a timeline [7], and inferred personality type based on a visual seeking performance tasks [1]. Log data has been found to be useful for reconstructing analytic processes [4]. However, creative processes are particularly difficult to analyze because they involve complex human activity that may lack clear goals and markers of progress. Because of this nuance, however, we find prior tools and methods are limited in how they help researchers characterize creative processes. Creative processes are nuanced and dynamic.

Prior research methods and tools for investigating creative processes are either rich, slow, and qualitative or inflexible and hypothesis-based. They lack capabilities for easily capturing and operating on complexity and nuance. In early Interaction Analysis (IA) [11] work, researchers recorded video of user verbal and nonverbal interactions. They later viewed the video and described participant actions and conversation. This method replaces biases of human memory with those of video recording. It involves production of hand-crafted transcriptions that describe human activity. IA and other researchers analyze and represent nuance with descriptive narratives and qualitative codes [23]. However, transcription is slow and expensive, commonly requiring 10 hours of human effort for each 1 hour of video. Tools for transcribing video and interaction [25] help researchers mange codes, but still require extensive effort for transcription.

New tools and methods are needed that take advantage both of human qualitative reasoning, for producing hand-crafted "codes", and also, broadly, to amplify human cognitive abilities. The present research aims to enable and amplify bottom-up approaches from qualitative methods using techniques from information visualization, search, and exploratory browsing. People engage in diverse creative processes, which can be complex. Thus, it is necessary to capture and operationalize nuance. We introduce the research agenda of Groma, a tool that enables qualitative labeling of the creative process as represented by interaction logs. To do this, it visualizes creative process over time, at multiple scales and provides methods for search by similarity. Rather than replacing HCI research methods, we are designing Groma to integrate the best of two often distinct worlds: qualitative reasoning and data exploration. This research develops a new way to characterize creative processes by supporting observation, labeling, pattern matching, and exploration of user actions from CSEs.

We have two overall goals: (1) design new interactive tools and methods for investigating creative processes and (2) perform a case study with the tools and methods, on the IdeaMâché CSE, to investigate creative processes of curation by students in a design course.

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2 RELATED WORK

2.1 Working with Qualitative Codes

In qualitative research practices, *phenomena* are *central ideas in the data represented as concepts* [2]. Phenomena, are meaningful occurrences, themes, and effects discovered in interviews and observations, the "data". Corbin and Strauss emphasize that researchers do not work with raw data, but create incremental representations of their understanding of phenomena and their causes. Qualitative researchers code data, creating labels that represent concepts as they discover phenomena.

> A theorist works with conceptualizations of data, not the actual data per se. Theories can't be built with actual incidents or activities as observed or reported; that is, from "raw data." The incidents, events, and happenings are taken as, or analyzed as, potential indicators of phenomena, which are thereby given conceptual labels [3].

Similarly, Interaction Analysis highlights the importance structuring events as *ethnographic chunks* [11]. Identifying these chunks is an interpretive process that is, like Corbin and Strauss' methods, grounded by data. While the timestamps on video tape provide absolute chronological time, they do not represent how people experience time. Instead, people think and reflect on time as a series of events. Many events have names and cultural significance: "setting the table" "giving advice" etc. Jordan et al. call these segments that contain actions *ethnographic chunks*. Identifying these boundaries of meaning is one of the first steps to transcribe and understand interactions. To do this, researchers draw from their own and participants' culture and experiences and consult prior research.

We refer to what people do with interfaces, interaction logs, interactions, and activity as *user actions*. Each user action is situated in time with a timestamp and may be connected other metadata. A *segment* of user actions includes a sequence of individual interactions bounded between a beginning and ending time. Using these definitions, we can create a structure for giving segments of user actions labels or codes, which represent concepts and ethnographic chunks from qualitative practices.

2.2 Interactive Analysis of Actions and Events

Other tools also use user action records to provide value and insight. Experiscope specifically targets evaluating interaction techniques [8], showing feasibility of instrumenting laboratory experiments for new interaction techniques It visualizes Individual user data, as well as aggregates, based on selections in a hierarchy. Case studies have shown reasoning processes can be inferred from interaction data [4, 9]. Brown et al. used mouse interaction in a visual search task to predict performance and personality of participants [1].

Work on timestamped events has enabled temporal search queries [20], summarization by replacing discrete sequences of events [14, 21], and surfacing and comparing events across time [18]. However, we view these representations of events as too rigid for creative applications. Our preliminary results show interactions may have both significant and less significant actions. Interactions can occur in parallel, e.g. a rapid opening and closing of a window. To deal with these noisy data, our approach emphasizes investigator qualitative reasoning to determine and articulate important patterns.

2.3 Human-in-the-Loop Approaches

Human-in-the loop approaches refers to fast iteration cycles that help people validate the quality of results. Endert et al. presented challenges and summarized how human in / is the loop approaches can benefit visual analytics [5]. They argue that existing human practices should be central in visual analytics applications. That is, one should build a system around human reasoning and practices. Information visualization can help people form insights using spatial reasoning; but even this is limited. Analytic algorithms integrated with interaction techniques and stand the best chance of helping. Our approach uses practices from Interaction Analysis, and builds a visual analytics system around it. Human-in-the-loop principles also apply to interactive machine learning [6].

2.4 Creativity and Curation

Creative processes involve learning and work. In Kaufman and Beghetto's Four C Model, creativity exist is personal (mini-c), amateur but shared (little-c), professional (Pro-c), and Eminent (Big-C) forms [12]. Each of these manifestations of creativity build on each other, escalating from mini-c insights (e.g. learning why pluto is not a planet) to universally novel discovery (e.g. penicillin). Thus, we see ideation as a kind of "work" and the main component of the creative process. It requires both flexible thinking, considering many perspectives, as well as persistence, following through with conceptual and tangible concepts [22].

Curation is a creative activity that has surged in popularity. Hundreds of millions of people use web curation tools such as Pinterest to manage and generate ideas [16]. Pinterest users conceptualize Pins as ideas and use boards to create unique solutions that address personal needs. Web curation supports creative ideation for addressing open-ended problems by allowing people to choose information and combine it in novel ways [13].

3 Preliminary Methods

We have developed and researched IdeaMâché (see `http://ideamache.ecologylab.net` for examples of curations), a web curation tool, to foster ideation and enable creative expression. Having this system has enabled us to gather data from real use in various college courses. In *The Design Process: Creativity and Entrepreneurship* (DPCE) course, students use IdeaMâché [10] to author creative solutions to open-ended problems. DPCE is an undergraduate course's designed to teach creative thinking skills applied to inventions of products, services, experiences, and art.

IdeaMâché provides zoomable and pannable canvas for curating media and information, where users drag and drop web content to assemble clippings of text, images, and videos into a whole. For annotation, users can write and draw freeform sketches. By manipulating visual styles, users can depict complex relationships among clippings and form new ideas and solutions. Students have used IdeaMâché to address open-ended problems, authoring useful and visually compelling curations and presentations [17, 15]. This has produced more than 10,000 hours of interaction logs. These logs are recorded in a structured database that enables looking at individual examples of curations made with IdeaMâché. Our preliminary results use a timeline to show how visualizing and labeling a timeline can be used to perform qualitative analysis at different scales of work, e.g. 10 hours, 3 hours, and 1 minute.

4 Preliminary Results

4.1 Analyzing 9 Hours of Curation

In this scenario, we ask *What are the creative processes of DPCE students' web curation?* We use is DPCE and the *Children's Peter Pan Inspired Room* curation as a case study. The DPCE student authored the curation across 3 major sessions, It is an example of looking at the visualization (Figure 1) to find interesting aspects to apply relevant creativity theory.

In this curation, Groma has recorded the user actions performed in the IdeaMâché application. Thus, each time a user gathers, visually styles, assembles, and annotates Groma records the user action. By retrieving all user action records for a particular curation, we form a new transcript of the user's creative processes automatically. We provide the work in progress visualization in Figure 1. Using this, as creativity researchers, we can look for interesting phenomena suggested and label segments and form ideas about ethnographic chunks. This requires exploring, collecting, and labeling segments of creative processes.

First, we look at the overall process of curation (Figure 1 A). We first notice three major segments. Note that there are three 2-hour sessions that concentrate movement. Looking at the row for drop_clipping, we notice that the most drop_clipping actions occur in the first movement. This is consistent with the dual model of creativity [22]. We see flexible thinking, a consideration of many perspectives, as well as persistence. Thus, even with a cursory observation, the visualization helps us investigate the creative process.

The next segment (Figure 1 B) shows more signs of persistence, including fewer drop_clipping actions and more organizational use. Annotation, through sketching and writing, are sparse in the first movement. In Figure 1 B, we can see that the author is changing from considering more web content to moving, scaling, and sketching them to create relationships.

Within Figure 1 B, we can see a pattern of use where zoom is quickly used after annotations. We expect that the author is trying to get an overview, to see if the drawn arrows need adjustments. To explore this, we created 20 segments of 1 minute around sketch actions, within Figure 1 B, finding that 13 of them followed the same pattern. Labeling these segments is equivalent to identifying "ethnographic chunks" in terms of [11].

Note that our analysis did not consider what should be coded as ethnographic chunks a priori. Instead, we grounded our observations based on the data we observed. Based on our observations, the the dual model of creativity [22] was appropriate. This method emphasizes researcher interpretation as a tool for investigation.

5 Proposed Work

Finding and labeling segments is not easy in the current version of Groma. Thus, by using Groma we find where it could better support IA researchers. Specifically, it motivates us to create features for search, making finding and labeling segments of user action easy. Our plan is to create an analytics dashboard which sup-

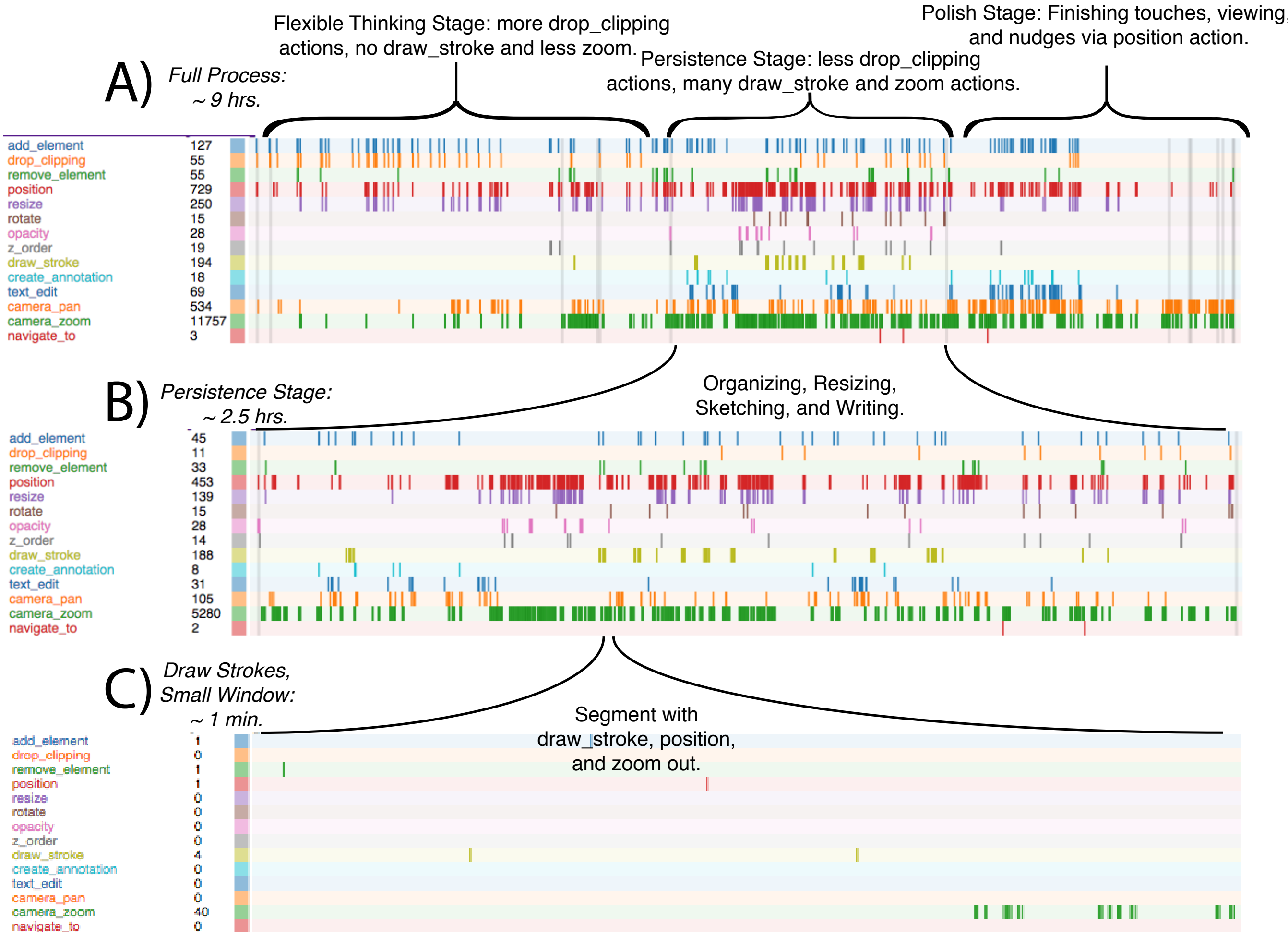

Figure 1: The creative process, via visualized user actions, of *Children's Peter Pan Inspired Room*. Each small rectangle represents a single user action. These are displayed over time, from left to right. Faint gray vertical bars indicate places where the user took break of 15 minutes or more.

ports labeling, managing, and finding segments (pattern matching) as researchers discover phenomena.

For Groma, we will include search and classification mechanisms that operationalize manually created labeled segments. Human-in-the loop approaches to machine learning use manually labeled data and algorithms to classify data automatically [6]. Thus, Groma will help researchers use manually labeled segments can be used to find new example of similar patterns of user actions. This operationalizes the qualitative reasoning common in IA and other methods, amplifying the intentions of researchers. We will support interactive machine learning [6] to support human-in-the-loop iterative analysis. For example, these labels could be use to find similar pattern in other curations using methods described in this proposal. It brings the best of both worlds, enabling rich and qualitative reasoning that can scale.

Aim 1: Support Human-in-the-Loop Creative Process Pattern Definition and Recognition. We will create an analytics workbench for visualizing, exploring, labeling, and collecting user actions: Groma. *Our research investigates how to support researchers in discovery of meaningful phenomena through iterative visualization, exploration, segment labeling, and pattern matching of creative process data.* Researchers using Groma will iteratively (1) explore visualizations of user actions; (2) qualitatively define and label meaningful segments of user actions; (3) use search and pattern matching features to find similar segments; (4) help researchers validate the results from search and pattern matching to grow labeled segments, keeping the human in the loop. We situate the design of Groma with a case study that investigates the curation processes of IdeaMâché, a CSE with signifiant classroom use.

Aim 2: Evaluate the Efficacy of Exploration Methods and Visualizations. We will perform a formative study of Groma and empirically evaluate the efficacy of its exploration, search, and pattern matching. *We hypothesize that formative evaluations will reveal that visualizing and exploring the creative process will be valuable to researchers, with an acceptable accuracy for search and exploration algorithms.* We will conduct a formative study to qualitatively explore the efficacy of labeling segments in visualized user actions while working with search and exploration algorithms. We will use standard information retrieval techniques [19] to evaluate the efficacy of search and pattern matching results. This will inform the design of future work, which is expected to scale to thousands of hours of interaction log data.

6 Discussion

Endert et al. describe visual analytics as a science that combines visualization, interaction, and algorithms to support exploration and discovery [5]. Their "human-is-the-loop" stance centers focus on human reasoning and practices. Qualitative methods [3, 11] share a very similar stance, that human experiences and knowledge are essential for identifying, categorizing, and developing theory about phenomena. In a sense, both visual analytics and qualitative methods have the same goal, a kind of storytelling. Both methods do not tell a story in a vacuum, but are grounded in qualitative/quantitative data. Visualizing user actions and providing a interactions for identifying qualitative coding could help bridge these concepts.

7 Questions for the Panel

What algorithms should be used for searching and clustering user action segments? Our goal is to enable soft matching of user action segment. As our preliminary results have shown, interaction logs can be noisy, but contain visually similar patterns. Our goal is to to avoid rigidity and provide expressive interfaces to parameters such as how similar time lengths must be, the extent to which order matters, and others. To achieving these goals, we must designing methods to transform user action segments into machine learning consumable numerical time segments.

What are alternative or additional timeline views that could communicate values with less visual footprint? The timeline presented in our preliminary results are useful, but very simple. Alternative representations (e.g. spiral instead of horizontal) may provide advantages to exploration in some case. Our goals are to make visualizations that have clear mappings and are useful for seeing many different scales of time (e.g. 10 hours, 1 hour, 1 minute).

What criteria and evaluation metrics should be used for assessing creative exploration? Groma will provide interactions where researchers build up examples over time. Researchers may not know what phenomena they are interested in finding. This poses a challenge in terms of evaluating pattern matching algorithms. For example, early in the process, more variability within search results might be better. Once there is a clear kind of phenomena, accurate results may be more important. This dynamic search need may require dynamic metrics for efficacy.

8 Conclusion

This research proposal defined objectives and plans the development of tools that enable researchers analyze creative processes in Creativity Support Environments. We positioned the research between among qualitative methods such as grounded theory and Interaction Analysis, information visualization, and information retrieval. Together, these inspire our plans for building Groma for capturing, identifying, and analyzing subtle patterns in creative processes. This integrated approach is expected to yield the following contributions: (1) new tools for characterizing creative processes in Creativity Support Environments; (2) a formative study of the how it would be used in practice (3) a quantitative evaluation of its pattern matching efficacy. These contributions, in turn, have the potential to advance help characterize creative processes in CSEs. With this new resource for researching interactions by people using CSEs, we expect the insights will lead to improvements in their design and the quality of life for people who depend on them.

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