Reflections on Creativity Workshops in Applied Visualization Research

Abstract: Creativity workshops are a flexible method that fulfill many purposes in applied visualization research --- they help researchers to establish rapport with project stakeholders, to understand domain problems, and to explore solutions to those problems. But visualization literature on previous workshops often reports what was done, leaving the reader to figure out how or why to do it. In this paper, we propose a series of insights that describe why and how to use creativity workshops in applied visualization research. Using a methodology of *critically reflective practice*, we examine our use of 12 creativity workshops in 8 applied visualization research projects spanning a variety of domains, including geographic information systems, defense, constraint programming, and neuroscience. We also analyze the underlying theory of creativity workshops, reviewing creativity literature and working closely with a creativity researcher. Three contributions arise from our reflection and analysis. First, we propose the concept of a *workshop focus*, to connect creativity workshops to existing visualization process and decision models. Second, we present a series of *20 actionable insights* supported by recommendations and considerations of using creativity workshops in visualization research. Third, we provide *two example workshops* as a starting point for visualization researchers to apply creativity workshops in their own projects. Overall, this work connects our experiential knowledge using workshops with underlying creativity theory to establish an understanding of how and why to use creativity workshops in applied visualization research.

In this document:

Compare our work to other workshop frameworks

Compare workshops to other methods

Introduction

[This section is out of date. I've moved it to our latex document while also significantly revising it. Please do not read or comment on it here.]

Creativity workshops are a valuable method for applied visualization research. Through the use of structured *creativity methods* [Biskjaer2017], workshops help visualization researchers in establishing rapport with domain collaborators, characterizing domain problems, and exploring solutions to those problems. Reflecting on their use of creativity workshops, Goodwin et al. [2013] conclude that the "*deliberate use of techniques to enhance creativity early in the visualization design process can contribute to success in terms of process and outcomes.*"

One benefit of workshops is that they serve as pre-design empiricism [Lam2012], creating artifacts that express the needs, concerns, and opinions of collaborators regarding both broad domain challenges and specific analysis needs. They allow for exploring a broad space of ideas and winnowing down to the most promising ones [Osborn1953]. They provide time to "*think about what to think about*" [Nickerson1999], and serendiptious interactions that lead to potentially transformative results. A workshop participant in a creativity workshop [Dykes2010] described their experience as "*highly valuable in the context where opportunities offered by information visualization can allow radically different approaches to [our domain problem].*"

Despite repeated successes, the visualization community currently has no established practices for what exactly is a creativity workshop, why they are important, or how to effectively use them. Previous projects report workshops with varying levels of detail. Goodwin et al. [2013] provide a rich description of a creativity workshop that was applied to subsequent projects. Kerzner et al. [2017], in contrast, describe their creativity workshop in one sentence. Even when workshops are described in detail, the intricate details of planning, piloting, running, and analyzing the results may be missing. Also, the visualization literature fails to communicate the experiential knowledge acquired through using workshops to fulfill many roles in diverse projects.

There are extensive resources on motivating, planning, and running workshops from the domains of creative problem solving and software engineering [Osborn1953,Hamilton2016,Jones,...Maiden…,]. While this work provides valuable background on workshops, it does not account for the nuances of visualization design, including: the critical role of data early in the design process [Pretorious2006,Munzner2009], the use of specialized process models [Tory2004,McKenna2014,Sedlmair2012], the sharing of knowledge between visualization researchers and collaborators [VanWijk2006], the fuzzy nature of visualization software requirements [Sedlmair2012], and the evolution of data and tasks that occur throughout a project [McCurdy2016].

In this paper, we reflect on the use of creativity workshops in applied visualization research. It results from a two year collaboration between applied visualization researchers and creativity practitioners. Through a methodology of *critically reflective practice* [Thompson2008], we have reviewed literature spanning both the theoretical and practical aspects of creativity workshops [Osborn1953,...,Hamilton2016]. We conducted creativity workshops and analyzed our past experience, having executed 12 visualization creativity workshops in 8 visualization projects [Goodwin2016,Kerzner2017,Kerzner2017:UPDB,Lisle2017,Nobre2017,Rogers2016,Goodwin2013,Walker 2013]. And we have reconciled our experiences in the field of visualization with an expert who has used creativity workshops in a variety of domains. Overall, this is the first comprehensive study on creativity workshops in applied visualization research. We hope that it communicates the experiential knowledge that we have developed during workshops are a valuable method and describe lessons we have learned from reflection on our experiences.

Contributions

Three novel contributions arise from the analysis of our experiences using workshops. First, we identify **constructs for describing our workshop experience,** including *recurring character roles* of individuals involved in workshops and the concept of *workshop focus* for characterizing creativity workshops by their intended role in visualization process and decision models (see sec:workshop experience). Using the workshop focus, we *winnow the scope of this paper to examine workshops used early in the design process, for characterizing domain problems and understanding analysis needs.*

Second, reflection on our experiences elucidates a series of ___ **actionable insights** that articulate our experiential knowledge and we believe are transferrable to future workshops (see sec:reflection). Analysis of the insights reveals a framework for using workshops consisting of four stages:

1. *workshop initialization* --- identifying workshop constraints and purposes;
2. *workshop design* --- selecting workshop methods;
3. *workshop execution* --- running the workshop and gathering artefacts; and
4. *workshop analysis* --- generating actionable insights from workshop results.

We support each stage of this process with a series of insights and we support each insight with a series of recommendations, considerations, and also identify relevant open questions for future work. The insights, recommendations, considerations, and open questions are all marked with unique identifiers that we use to explicitly connect relationships between concepts.

Third, we provide **example workshops** plans that serve starting points for visualization researchers to apply creativity workshops to their own projects (see sec:example workshops).

Structure of this paper

In this paper, we summarize the related work to creativity workshops in applied visualization research. Next, we summarize our workshop experience and introduce the constructs for describing creativity workshops. We describe our research process, multi-method analysis for generating insights from experiential knowledge. From this analysis, we introduce the concept of workshop focus and use it to categorize different workshops. We focus our reflection on workshops used early in the visualization design process, and propose a series of insights. We conclude with a discussion and highlight areas for future work.

Related work

Included in this section are: 1) a definition of creativity, creativity workshops, a background of creativity and creativity workshops for problem solving and software engineering and 2) a summary of workshops in visualization.

Creativity and creativity workshops

The vocabulary around creativity workshops is overloaded as it intersects with the fields of design, psychology, business, art, and business. Broadly, **creativity** consists of four main principles. First, it is commonly defined as the generation of ideas that are both new and useful [Mayer1999]. Second, psychologists studying creative individuals reveal that creative ideas result from hard work, open communication, and series of mini-interconnected insights [Sawyer2006]. Third, in design, a creative process is one that encourages divergent thinking to explore many ideas, followed by convergent thinking to select the most promising ones [Lowgren1995]. Fourth, when considering creativity in collaborations, it can be characterized as a synergistic phenomena that emerges from interactions between group members [Sawyer2003]. When talking about creativity workshops, we are referring to workshops that embrace all four characteristics to some extent.

Another way to describe creativity workshops is by the actions of designers. More specifically, **methods** are the repeatable procedures that describe actions of designers [Crotty1998]. As the name suggests, **creativity methods** are methods that encourage creativity --- to some extent all methods used in visualization design are creativity methods because of the underlying nature of design [Biskjaer2017]. **Workshops** are the structured use of methods to achieve a goal [Brooks-Harris1999]. **Creativity workshops** are the structured use of creativity methods to achieve a goal. Just as all methods can be considered creativity methods, all workshops can be considered creativity workshops to some extent. The distinction between creativity workshops and workshops is often based on intent rather than observable differences [Hamilton2016].

Creativity in psychology. Creativity workshops originated in the field of creative problem solving, which is closely related to the study of creativity from the perspective of psychology. The psychological study of creativity underlies the modern processes for creativity workshops. Guilford is credited with starting the modern study of creativity with his speech to the APA that connected the study of creativity and

intelligence [Guilford1953]...Two common models emphasize the importance of thinking and doing in creative endeavors: the four stage model and the action theory of creativity. The four stage model defines a linear sequence of creative thoughts as preparation, incubation, insight, and elaboration. This model, however, oversimplifies human thought and understates the role of action in creativity [Sawyer2006]. The action theory of creativity emphasizes the importance of action in a feedback loop: as creators express an idea, the world reacts to that expression, and this reaction influences the creator, changing their idea and leading to new ones [Sawyer2006]. These two models provide a useful vocabulary to describe creativity methods and workshops. There are many other models for characterizing the creative process and classifying types of creative thoughts, please see Mayer et al. [Mayer1999] for a summary of creativity research.

Creativity workshops. Creative problem solving practitioners are credited as the first individuals to create methods and workshops that harnessed creativity for a specific purpose [Nickerson1999]. This field ranges from recommendations for creativity methods, such as brainstorming [Osborn1953] to methodologies, such as Creative Problem Solving [CreativeEducationFoundation2015] and Synectics [Gordon1961]. Principles of these methods and methodologies include: encouraging convergent and divergent thinking [Osborn1953], fostering a creative atmosphere by suspending judgment [DeBono1983], stimulating creativity through analogy [Gordon1961], gaining new perspectives on a problem through metacognition [VonOech1986], and using both analytically and intuitive mindsets [Miller1989]. Applying these guidelines to visualization creativity workshops is labor intensive, in part, because creativity for problem solving assumes that workshop participants have the necessary knowledge to solve their own problems. In contrast, visualization research emphasizes the importance of sharing knowledge between domain collaborators and visualization researchers to reach a solution [Wijk2006].

Creativity workshops in software engineering. Software requirements engineers recognize that generating requirements requires creativity [Robertson2002] and researchers have tailored existing creativity methods and methodologies, such as Creative Problem Solving, to their field [Maiden2010]. This includes creativity workshops to engage project stakeholders and to elicit requirements for complex systems [Jones2008,Maiden2004,Maiden2005,Maiden2007]. Common parameters of these workshops include a length of 0.5 to 2 days, 18 - 24 participants, and hundreds of ideas generated per workshop [Jones2007]. These ideas generated were integrated into requirements engineering processes [Jones2005] or more modern agile processes [Hollis2013]. Although these workshops also provide useful guidelines for visualization workshops, they mention data only implicitly [Jones2017], in contrast to the important role of data early in the visualization design process [Lloyd2011]. There is also no clear relationship between the use of workshops and existing visualization design processes.

Creativity workshops in visualization

The term *workshop* is overloaded in visualization literature and appears in a various methodologies for including collaborators in the process of visualization design. For example, Koh et al. [2011] describe a methodology that recommends the use of *visualization awareness workshops* --- to show collaborators

general visualizations and elicit requirements by example --- and *domain visualization workshops* --- to show collaborators example visualizations using real data. However, subsequent work used *visualization awareness* as a method, as part of a larger workshop [Goodwin2013]. Slingsby et al. [Slingsby2012] describe a process of focused short term collaboration involving participatory methods for understanding current practices, designing, prototyping, and evaluating prototypes. These processes encourage the use of workshops in applied visualization research, but fall short of prescribing guidelines or specific methods.

The first instance of a project that used methods resembling a creativity workshop was reported by Dykes et al. [2010] who described a series of imagination exercises for eliciting requirements from geographic information systems (GIS) collaborators. The term *creativity workshop* was introduced to visualization by Goodwin et al. [2013] who describe the explicit mapping of software engineering creativity requirements workshops to our field. This work inspired our use of creativity workshops in a variety of additional projects [Goodwin2016,Kerzner2017,Kerzner2017:UPDB,Lisle2017,Nobre2017,Rogers2016].

Despite the repeated successes using creativity workshops described in these projects, there are currently no established practices for visualization creativity workshops. We have been involved in *every* workshop described in this subsection and draw on our experiences through the remainder of this paper.

Workshop experience

Our collective experience includes 12 workshops in 8 diverse projects. This section describes the projects where we used workshops, and summarizes characteristics about specific workshops.

Projects. We have used workshops in a variety of projects. The projects are in this table:
This will be typeset as a nice latex table. It's included here so we can comment on it.

Project name	Author	Domain	Collaborators	Goal	Workshops	Result
EDINA (P1)	Dykes	GIS	Industry	*"Reimagine the legend in the context of vis"*	1	InfoVis paper [Dykes2010]
E.ON (P2)	Goodwin	Energy	Industry	Deliver insights into the role of Smarthomes and new business potential	4	InfoVis paper [Goodwin2013]
HTVA (P3)	Walker	Human terrain	Defense	*"Develop [visualization] techniques that are meaningful in HTA"*	2	InfoVis paper [Walker2013]
CP (P4)	Goodwin	Constraint programming	Academic/ Industry	Design visualisations for performance profiling methods for constraint programmers	1	VAST paper [Goodwin2016]
Graffinity (P5)	Kerzner	Neuroscience	Academic	Create novel visualization techniques for multivariate graphs	1	EuroVis paper [Kerzner2017]
Lineage (P6)	Nobre	Psychiatry	Academic	Create visualizations to support genealogy analysis	1	TVCG paper [Nobre2017]
UPDB (P7)	Kerzner	Genealogy	Academic	Create visualizations to support genealogy analysis	1	---

						[Kerzner2017:UPDB]
Arbor (P8)	Lisle	Biology	Academic	Create visualization software for phylogenetic analysis	1	NSF grant application [Lisle2017]

Note the diversity of projects: different experience of researchers (senior faculty to grad students), different domains, different types of collaborators (academic and industry). We'll use the **project name** to refer to projects throughout the paper.

(Continuation of table from above. Need this info for figures.)

Project name	Author	Start date	End date
EDINA (P1)	Dykes		
E.ON (P2)	Goodwin	Jun 2012	Mar 2013
HTVA (P3)	Walker		
CP (P4)	Goodwin	Apr 2015	June 2016
Graffinity (P5)	Kerzner	May 2015	May 2017
Lineage (P6)	Nobre	Aug 2016	In progress
UPDB (P7)	Kerzner	Jan 2017	Jan 2017
Arbor (P8)	Lisle	Apr 2017	In-progress

(*agree on the table content here, we'll figure out the formatting in latex)*

Project name	Workshop id	Workshop goal	Duration (approx. hours)	Primary focus
EDINA	[edina]	Explore possibilities for enhancing legends with visualizations	(?)	Requirements
	[edina:eval]	(?)	(?)	Evaluation
E.ON	[eon]	Identify ways of utilising smarthome data/technologies	6	Requirements
	[eon:design]	Develop concepts from requirements workshop in an agile approach	4	Design
	[eon:feedback]	Elicit feedback from prototypes	3	Design
	[eon:evaluation]	Elicit feedback from final designs	3	Evaluation
HTVA	[htva]	Establish current practice and perceived needs	(?)	Requirements
	[htva:evaluation]	Acquire feedback on progress and additional requirements	(?)	Evaluation
CP	[cp]	Identify data analysis and visualization opportunities	7	Requirements
Graffinity	[graffinity]	Find opportunities for visualization in retinal connectomics and identify shared user needs	7	Requirements
Lineage	[lineage]	Understand the main domain tasks of collaborators	3	Requirements

UPDB	[updb]	Find opportunities for a design study with genealogy researchers	3	Domain characterization
Arbor	[arbor]	Find opportunities for funded collaboration between visualization designers and biologists	7hrs x 2 days	Domain characterization

Project name	Workshop id	Key stakeholder	Workshop Team (incl. co-facilitators)	Participants: Domain collaborators	Participants: vis designers
EDINA	[edina]	1 vis researcher (JD)	(?)	7 employees of EDINA GeoSpatial Services	(?)
	[edina:evaluation]		(?)	(?)	(?)
E.ON	[eon]	1 vis researcher (SG) with good domain knowledge.	Professional Facilitator (Creativity researcher)| 1 * vis researcher (JD)	5 employees of Forward Thinking Tech. Team	0
	[eon:design]		1 vis researcher (in previous) (JD)	0	5 visualization researchers
	[eon:feedback]		1 vis researcher (in previous) (JD)	7 analysts, 4 from R Workshop	0
	[eon:evaluation]		1 vis researcher (in previous) (JD)	5 analysts, 4 from R workshop	0
HTVA	[htva]	1 vis researcher (JD)	1 vis researcher	5 defense analysts	8 vis researchers
	[htva:evaluation]		1 vis researcher	5 defense analysts	8 vis researchers
CP	[cp]	Vis researcher (SG) with basic domain knowledge	1 vis researcher (with good domain knowledge) | 1 domain researcher	10 constraint programmers	
DiscoveryJam '16	[discoveryjam2016]	----	4 vis researcher (EK) | 2 domain scientists	0	20 - 40 attendees of IEEE Vis
Graffinity	[graffinity]	1 vis researcher (EK)	4 vis researchers	9 analysts and support staff	0
Lineage	[lineage]	1 vis researcher	2 vis researcher (EK)	6 genealogy psychiatric analysts	1 vis researcher
UPDB	[updb]	----	1 vis researcher (EK)	7 analysts	3 vis researcher
Arbor	[arbor]	1 vis developer and 1 vis researcher	1 vis researcher (EK) | 1 biologist	10 biologists	2 vis researcher
DiscoveryJam '17	[discoveryjam2017]	----	6 vis researcher (EK) | 2 domain scientists	0	30 vis attendees

Note the diversity of workshops: wide range of participants, range of durations, and variety of types. This establishes broad experience using workshops with a variety of goals.

Project name	Workshop id	Date
EDINA	[edina]	
	[edina:evaluation]	

E.ON	[eon]	Sep 2012
	[eon:design]	Nov 2012
	[eon:feedback]	Jan 2013
	[eon:evaluation]	Mar 2013
HTVA	[htva]	
	[htva:evaluation]	
CP	[cp]	Nov 2015
Graffinity	[graffinity]	Jul 2015
Lineage	[lineage]	Mar 2017
UPDB	[updb]	Jan 2017
Arbor	[arbor]	Apr 2017

Next, we describe the columns of this table in more details. Specifically, we unpack the character roles that commonly occur during workshops, the four types of workshop focus, and the workshop goal.

Workshop characters

Initial analysis of our experience revealed recurring character roles of the individuals involved in visualization creativity workshops. These roles include: *workshop stakeholders, a key stakeholder, workshop team, the facilitator, the co-facilitators, and participants.*

The **workshop stakeholders** include all individuals with an interest in the outcomes of the visualization research project. Stakeholder is a broad term that encompasses the visualization researcher(s), domain collaborator(s) and potentially fellow tool builders. This term is broadly used to describe collaborators in workshops for software engineering [Maiden2004(?)].

The **key stakeholder** is the visualization researcher primarily responsible for using the workshop output in a visualization research project. This term is from guides for running workshops in a business setting [Hamilton2016]. In our experience, the key stakeholder is usually the first author on resulting visualization publications [eon, cp, graffinity, lineage].

The **workshop team** is the set of individuals who carry out the workshop by facilitating the methods and discussions. The workshop team usually includes one **primary facilitator** who is responsible for coordinating the actions of other team members. It also consists of one or more **co-facilitators** who

assist the primary facilitator. The workshop team is typically 2 - 4 visualization researchers, domain collaborators, or creativity experts.

Understanding the difference between the *key stakeholder, the workshop team, and primary facilitator* is critically important for successful projects. One of our workshops failed because these roles were not clearly defined [updb] (see also: cast characters). In our experience, the key stakeholder can serve as the primary facilitator of workshops [graffinity, cp]. Key stakeholders may also be co-facilitators [eon, arbor, lineage]. Workshop literature generally discourages the key stakeholders from participating in workshops [Hamilton2016,CPS2015].

The **participants** are the individuals who participate in the workshop. They carry out methods led by the workshop team. The participants can include domain collaborators, visualizations researchers, and other project stakeholders. The ideal participants depend on the intended role of the workshop in the visualization design process, which we describe next.

Workshop focus

Initial analysis of our experience illuminates the concept of **workshop focus**---a categorization of workshops based on their intended role in the visualization design process. The workshop focus emerged from synthesizes of our experiences, a review of existing visualization design and process models, and existing methodologies creative problem solving.

We identify four distinct areas of workshop focus, summarized by this table:

Workshop focus	Description	Design activities	Nested model	Ideal participants
Domain characterization	Provides broad characterization of domain problem space.	Understand (generative)	Problem characterization	Domain collaborators
Requirements	Identifies specific analysis needs suitable for a design study	Understand and ideate (generative)	Data/operation abstraction	Frontline analysts
Design	Explores the solution space for specific problems.	Ideate and make (generative)	Encoding/interaction technique	Visualization designers
Evaluation	Evaluates visualization solutions with collaborators.	Deploy and understand (evaluative)	Downstream validation	Domain collaborators

The four workshop focuses correspond roughly to the four levels of the Nested Model for Visualization Design [Munzner2009]. They also map to design activities of the DAF [McKenna2014]. The four workshop focuses are: domain characterization, requirements, design, and evaluation.

First, **domain characterization** workshops generate a broad understanding of domain needs,without necessarily identifying specific analysis tasks. This maps to the understand activity. Output from the workshop influences the domain problem characterization of the nested model.

Second, a **requirements workshops** focuses on the needs of specific data analysts. It corresponds to the understand and ideate design activities. Output from these workshops influences decisions at the problem characterization and data and task analysis levels of the nested model.

Third, **design workshops** involve ideating or creating designs to fulfill the needs of analysts. This fulfills the ideate and make design activities, and the interaction, encoding, and implementation levels of the nested model.

Fourth, **evaluation workshops** focus on evaluating, validating,and eliciting feedback on visualization solutions for a given domain. This corresponds to the make and deploy activities while providing data used in downstream evaluation of the nested model.

Hedge the workshop focus. Workshop focus abstracts and simplifies the intended outcome of complex activities and interactions. Moreover, the boundaries between focuses is ill-defined and workshops could be interpreted as spanning different focuses. This is due, in part, to the difficulty of predicting the serendipitous and emergent group creativity that occurs during a workshop. It is also due to the use of methods spanning different design activities within a workshop. For example, while a workshop may be focused on characterizing domain problems, the methods in that workshop may also explore possible solutions as problem-finding and problem-solving are inherently linked in the design process [Buchanan1992].

Nevertheless, we believe that workshops should be used to fulfill a need in the design process (see: workshop purpose). Identifying this purpose through the construct of workshop focus is valuable for describing, comparing, and analyzing our experiences. It is also valuable to researchers for thinking about their workshops in the context of the insights, recommendations, and considerations of this paper.

Workshop methods

The **methods** are the repeatable procedures that describe the activities of workshop participants. Creativity methods have been extensively studied by domains including design (e.g., [Biskjaer2017,Sanders2008]), creative problem solving (e.g., [Gordon1961,Osborn1953,VonOech1988]), education (e.g., [Brooks-Harris1999,Stanfield2002]), and visualization [McKenna2014]. While we attempted to use this work to describe our experiences in creativity workshops, we found that none of it completely addressed the challenges of using creativity workshops in applied visualization research. In this section, we propose a series of **method attributes** to provide a vocabulary for selecting methods to create coherent workshops in the context of applied visualization research.

The method attributes are grouped into four categories: *concrete aspects, conceptual aspects, design space aspects and visualization aspects*. First, **concrete aspects** are the practical and physical considerations for conducting a creativity method. Second, **conceptual aspects** relate to the intended effect of the method on the emergent creativity or emotions of the workshop. Third, **design space aspects** describe the intended influence of the method on the design space and the creative mindset. Fourth, **visualization aspects** describe the extent to which data, analysis, and visualization are included in the methods. Next, we introduce each aspect as well as the associated attributes.

(These category names and definitions extend those described by [Biskjaer et al. 2017].)

Concrete aspects

Concrete aspects are useful for describing the actions of the workshop team and participants, they include: the *process, structure* and *components*.

Process

The **process** are the steps used to carry out the method. The process includes a description of how methods will be carried out, including the intended duration, the physical movement of individuals, assignment of participants to groups.

Structure

Related to process is **structure.** The structure of method process refers to the instruction provided to participants and the intent of the facilitator to guide the participant's thought process. An example **unstructured method** is *Brainstorming*, the freewheeling generation of ideas [Osborn1953]. An example **structured method** is *Wishful thinking,* where participants generate aspirations to some prompt.

Components

The process and structure describe how a method uses or produces **components,** the physical artifacts in the method. More specifically, components include the **prompt** to present information or communicate process to participants (e.g., physical handouts or slides), the **materials** which are transformed through the method into artifacts (e.g., post-it notes or posterboard), the **tools** used to transform materials (e.g., markers, scissors, pens, tack).

The artifacts can be referred to as either **input** or **output** to a method or to a workshop.

Conceptual aspects

These aspects are useful for describing the intent of methods on participants and emergent ideas, including the agency, communication, and externalization.

Agency

The **agency** relates to the ownership, self-expression, or responsibility of workshop participants.

Ground rules for the day, such as "suspending judgement" and "everyone participates" can help encourage agency.

Lectures are notorious methods for discouraging agency as reported by Lloyd and Dykes [2011].

Communication

Related to agency is the **communication** or extent to which the method promotes open communication by, for example, establishing trust by showing vulnerability or encouraging interpersonal leveling.

Introduction methods, such as *introduce yourself as an animal*, promote open communication by displaying vulnerability.

Externalization

Communication is supported by the **externalization**, or physical media to communicate such as through spoken word, written ideas, drawings, or other physical media.

The externalization is important to consider, because, for example, small group discussions are often ephemeral and lost after the workshop. Small group discussions that support externalization preserve output.

These is also evidence from creativity research that explicitly externalizing your idea is essential for creativity [Sawyer2006].

Design space aspects

The design space aspects describe how methods encourage participants to think about ideas, in general. These are closely related to existing research in visualization and design. They include the idea space, the iteration, and the creativity triggers.

Idea space

The **idea space** is concerned with the effect of a method on an idea space. **Divergent methods** expand the idea space, generating new ideas, supporting exploration and risk taking. Example divergent methods include *Wishful Thinking, Brainstorming,* and *Personas.* **Convergent methods** winnow the idea space, evaluating ideas, or focusing on more promising ones. Example convergent methods include *Clustering and Ranking*.

Both divergent and convergent methods can encourage **iteration** on ideas, by revisiting concepts throughout the workshop. Iteration involves the extent to which methods explicitly draw on the outputs of earlier ideas. For example, constraint removal is highly iterative in that it involves changing the outputs of an earlier method. Storyboarding is less iterative because it relies on the mental synthesis of ideas.

(In all these cases the categorization often relies on the *intent* for using the method and the method's execution within the workshop. For example, *storyboarding* is generally used as a convergent method to synthesize ideas from the day into a cohesive story [eon,graffinity,cp], but it may also be used as a generative idea to elicit ideas about possible designs.)

Creativity triggers

Related to idea space are the **creativity triggers**, which discuss how creativity is stimulated or encouraged. Such as through metaphor, analogy, or incubation.

Creativity attributes also include the extent to which methods encourage participants to break from existing thought paradigms.

Visualization aspects

Visualization aspects are concerned with the relationship between participants, their data, and their analysis tools. They include: data context, analysis context, and automation context.

Data context

The **data context** is the extent to which methods elicit ideas about participant's data and whether those ideas are based in real data or the participant's perception of data.

Methods usually involve perceptions of data. For example, *wishful thinking* asks participants about what they want to know about their data in the abstract. But methods can also involve real data, such as the workstations we provided in [DiscoveryJam17]. (In discoveryjam, we had machines with the scientists data and paraview ready to go. Participants tried to use it, but there were too many technical barriers. This seems interesting. For example, *how do we reconcile the existing visualization canon that real data is critical with the challenges of exploring real data in the limited time of a workshop?)*

Methods can also be used to generate an understanding of the characteristics of data --- such as the method that aimed to identify surrogate data in [htva].

Analysis context

The **analysis context** describes how methods elicit ideas about the software tools or workflows for analyzing data.

Most workshops deal with analysis context in the abstract --- methods are aimed at understanding the perception of analysis context. This was true in [eon] where we were not constrained by existing workflows to explore possibilities. In contrast, the [graffinity] workshop was more concrete --- we used screenshots of existing tools to elicit ideas during the wishful thinking method. The [htva] and [edina] workshops asked concrete questions about existing tools, such as "what do you do well?" but did not involve screenshots of tools in the methods. (Likely guidance: balance analysis context with goal of collaboration)

Automation context

The automation context describes the extent to which participants expect to perform the actions of the analysis. In other words, it tries to capture how well defined are their domain tasks and whether participants perceive the tasks as something that can be automated.

(I'm not sure what we can say about this, but it seems interesting. For example, what if we asked in wishful thinking: What would you like *the computer* to know? What would you like *the computer* to do?)

(This also related directly to the task definition and information location axes of the design study methodology)

Purpose of attributes

These attributes are abstractions of inherently interconnected concepts dealing with cognition, emotion, creativity, and data analysis. They should be judged by the extent to which they enable us to describe our experience and to ask interesting questions about future workshops.

Attributes of a previous workshop

This subsection demonstrates the descriptive power of our method attributes. We retroactively examined the attributes of a workshop used in the project …. We have described additional workshops using these attributes as included in the supplemental material...

Research process

Our research on visualization creativity workshops results from 2 years of collaboration between visualization designers and creativity researchers. The following question underlies our collaboration, research methodology, and research methods: *how should we share our experiential knowledge about workshops with the visualization research community?* This question relates to a key challenges already familiar to applied visualization researchers: *how should we articulate tacit knowledge about workshops?* This section describes the methodology of *critically reflective practice* and methods that we used to articulate our experiential knowledge and generate insights transferrable to future projects.

Methodology

This work is based on reflection**,** the analysis of experiences to generate insights [Boud1985]. We have applied a methodology of **critically reflective practice** [Thompson2008], defined as "*a process of synthesizing experience, reflection, self-awareness and critical thinking to modify of change approaches to practice."* Critically reflective practice extends two forms of reflection proposed by Schon [1982]. Schon identified *reflection-in-action* and *reflection-on-action* where the former refers to the analysis *during* experiences and the latter refers to analysis *after* experiences to generate insights and make sense of experiences. Critically reflective practice adds a third category *reflection-for-action* which aims to prescribe changes to future practices [Thompson2008].

The visualization community recognizes the critical role of reflection in research as Sedlmair et al. [2012] say: *"reflection is where research emerges from engineering ...Reflection on how a specific design study relates to the larger research area of visualization is crucial for adding to the body of knowledge and allowing other researchers to benefit from the work."* In this work, we reflect on our experiences using creativity workshops across a series of diverse design studies to suggest changes to future practices.

Critically reflective practice is appropriate for analyzing our experiences when compared to other research approaches. Critically reflective practice captures experiential knowledge and subjective interpretation of experience that is omitted in grounded theory, thematic analysis and similar qualitative methods. Critically reflective practice also accounts for the messy nature of applied research where controlled experiments are not feasible.

Critically reflective practice is inherently subjective and we recognize our own backgrounds and biases and recognize that they influence the results of our research. We are applied visualization researchers with diverse backgrounds including GIS, biology, and interactive graphics. One co-author is a creativity researcher with extensive experience using creativity methods to elicit software requirements and integrating new technology into creativity practices. Through rigorous reflective methods, we have reached a consensus on the interpretation of our experiences and agreed on prescriptive guidelines for future workshops. We also recognize that concepts where we could not reach a mutual understanding or highlight interesting areas for future work. Next, we provide an overview of the timeline of our experiences followed by a description of the methods used to reflect on our workshop experiences.

Timeline

The methods of our critically reflective practice span the past seven years of using creativity workshops in applied visualization research (see the timeline below).

Year(s)	Workshops	Our analysis
2004 - '09	Creativity workshops applied to software req. engineering	
2009	EDINA workshop	
2010 - '13	E.ON workshop and HTVA workshop	Applied software req. workshops to visualization
2015	Graffinity workshop in design study CP workshop in design study	Reconciled differences of workshops Speculated on guidelines for future workshops Reviewed literature with narrow scope: creativity methods
2016	DiscoveryJam Workshop	Reviewed literature broadly: creativity, creativity support Analyzed E.ON and Graffinity workshops in detail
Spring 2017	UPDB workshop Lineage workshop Arbor workshop	Revisited experiences, interviews on EDINA and HTVA projects Interviewed software req. engs about creativity workshop Reviewed literature on workshops for business, problem solving
Fall 2017		Identified 85 mini-insights from previous discussions and analysis Writting: create insights supported by recommendations, and considerations

Caption: The **Workshops** column chronicles our experience running workshops. The **Analysis** column shows how our critically reflective practice developed over two years. All of the work up into fall '2017: focused on *reflection-in-action* and *reflection-on-action*. This paper is the result of *reflection-for-action* as we intend to communicate insights transferrable to future visualization projects.

Our concerted effort to reflect on creativity workshops began two years ago through discussions about our experiences in the [eon] and [graffinity] projects. Through approximately ____ hours of discussions via skype and ___ hours of in-person meetings, we shared the *reflections-in* our experiences and tried to generate *reflections-on* our experience, such as reconciling the differences between experiences, speculating on changes for future workshops, and reviewing relevant literature. Throughout these discussions, we continued to run workshops incorporating bits of our reflection in the process. This

piecemeal effort provided us an understanding of our experiences, but fell short of creating prescriptive guidelines for future projects.

In the past six months, we transitioned to *reflection-for-action,* distilling our experiential knowledge into actionable insights transferrable to future projects. We analyzed all of our past workshops, including the project context, goal, materials, methods, tools, participant feedback, output artefacts. We also examined the methods used make sense of workshop output and the role of the workshop output in the results of each project. This analysis occurred through ___ hours of in-person meetings, ___ hours of discussion through skype, and countless hours of individual analysis. The exact methods of reflection are described next.

Methods

To analyze our experiences and multiform workshop data, we used **observations-to-insights**, a method of *"learning from what is observed in research by revealing nonobvious inner meanings"* [Kumar2012]. We also used **insight sorting** a method to *"find clusters and hierarchies"* of insights [Kumar2012]. Initially two co-authors performed these methods. The remaining co-authors then examined, evaluated and revised the concepts until we reached consensus. The remainder of this section describes our use of these methods to create our reflections on visualization creativity workshops.

Observation-to-insights is a method for systematically generating insights from data and tacit knowledge. We applied this method in two stages: identifying observations and generating insights.

Identifying observations: First, we identified *87 observations* from our past discussions, workshop data, and creativity literature. Observations had many forms, ranging from methods that were used in the workshops, to characterizing the duration of all workshops, and the analysis methods for making sense of workshop output. Each observation synthesized details from our experience with existing references in the visualization, and creativity literature. The observations were generated by two co-authors over approximately three weeks of analysis.

Generating insights: Next, we generated **insights** from the observations. Insights provide a high-level grouping of our observations. They are *"a holistic understanding of the true nature of something"* [Merriam-Webster2017]. Insights summarized the results of one or more observations. As we aim to improve practices for future workshops, we created insights with prescriptive statements (an insight, e.g., **"Well-defined workshop scope allows for openness and exploration"**).

During the insight generation, we also identified whether the observations could be used to prescribe changes for future practices. We categorized each observation as a *recommendation, a consideration, or an open question.* **Recommendation** are suggestions as to a likely beneficial course of action. They emphasize prescription and are often based on a convergence of both our experiences and prior literature. **Consideration** are ideas that should be taken into account while planning a workshop. **Open**

questions highlight interesting area where we lack knowledge or experience to address. These provide opportunities for future research. Open questions may include speculation, based on circumstantial evidence from our experience.

Considerations and recommendations are of equal importance. Considerations are ideas where there is no convergence as to the likely beneficial course of action, or where visualization researchers may not have control.

Insight sorting was performed by two co-authors and revealed four categories of insights. These roughly correspond to workshop initialization, design, execution, and analysis (described in more detail in the next section). The insight sorting was influenced by previous workshop literature which usually discusses the process of using workshops temporally [Hamilton2016,Brooks-Harris1999,...]. It was also influenced by our earlier discussions about the process of using workshops in research projects.

The results of the observations-to-insights and insight sorting was a series of insights, recommendations, considerations, and open questions. This was evaluated by the remaining co-authors for accuracy, consistency, usefulness, trustworthiness, descriptive power, … Through this evaluation, we identified ___ additional insights and ___ additional observations and recommendations. We also removed ideas that were deemed redundant or inaccurate. The resulting insights, recommendations, considerations, and open questions are presented in the next section.

Reflections on Visualization Creativity Workshops

[This section is now out of date. I am rewriting it in a latex document. Email me for access.]

This section presents the results of our reflection-for-action as a series of insights, recommendations and considerations. We have focused our reflection on workshops used early in the design process. While the concepts in this section may apply to other workshops types, we intend for them to be useful for characterization and requirements workshops. For example, one of the recommendations includes "*concentrate on problems, not solutions"* which would not necessarily apply to *design* workshops aimed at generating solutions.

The insights are grouped into four stages: *workshop initialization, workshop design, workshop execution, and workshop analysis.* These four stages, described in detail below, outline framework for using creativity workshops in applied visualization research. (They are also in a figure on the next page).

Workshop initialization consists of the deciding to run a workshop, selecting a useful workshop focus, and identifying stakeholders and constraints. Output from this stage include identified workshop focus, goal, team, and ideal participants.

Workshop design focuses on selecting methods for the workshop. As suggested by the term *design*, this is an iterative process that involves selecting methods from a variety of sources, tailoring them to the

specific workshop, piloting them, and improving them based on the pilot results. Output from this stage includes the *workshop plan*.

Workshop execution refers to the process of actually performing the workshop. It includes effectively facilitating discussions and gathering artefacts from the workshop methods. Output from this stage are the artefacts from workshop methods and experiential knowledge of the workshop team.

Workshop analysis involves making sense of the artefacts and experience from the workshop. This is where the results of the workshop form actionable knowledge.

We introduce and discuss each category by presenting a series of insights developed through our reflection. We support each insight with a series of recommendations, considerations and open questions. The structure of insights in this section is:

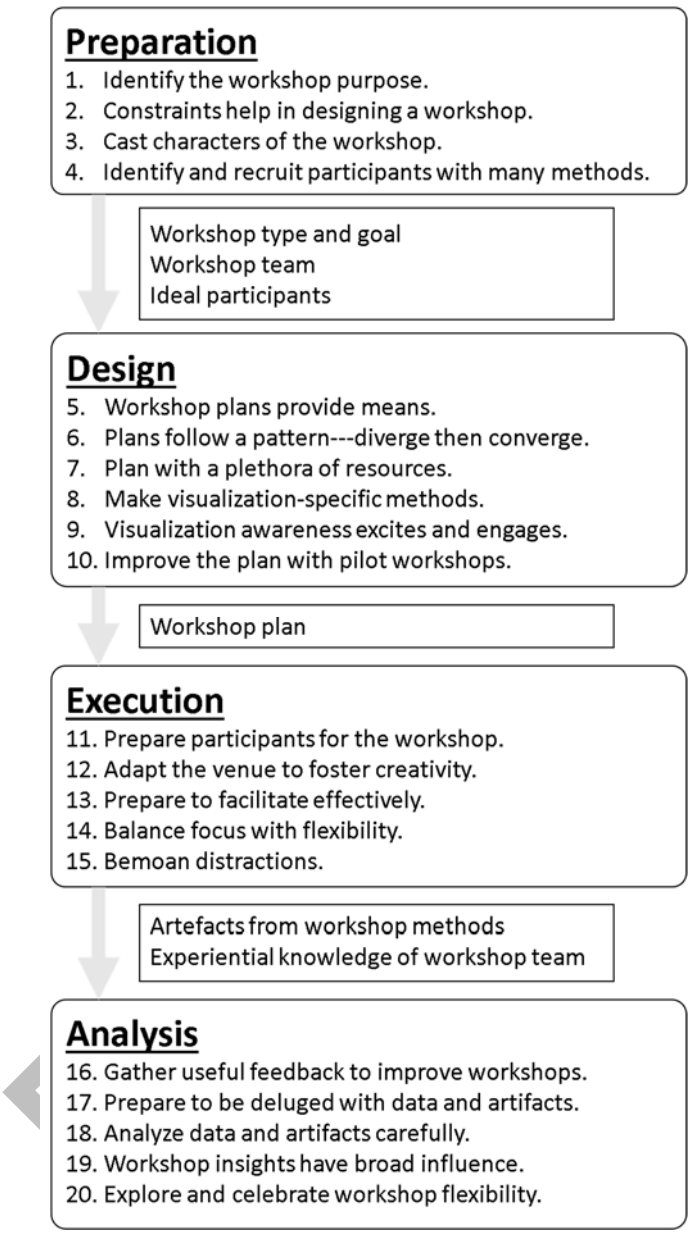
This is an insight with a unique identifier (heading 3)

Short description of the insight.

Recommendation: this is a recommendation, also with another unique identifier (heading 4)

- Description, context, or supporting evidence of the recommendation.
- Considerations and open questions are presented in the same format.
- Cross references are linked to other identifiers
- Vis: marks an idea that is specific to workshops in visualization projects instead of creativity workshops in general.

The following figure summarizes the four categories and their supporting insights.



Caption: overview of our insights about preparing, designing, executing, and analyzing visualization creativity workshops. The stages and insights cascade. For example, the output from workshop initialization provides important constraints for the workshop design.

The stages of this framework identify cascading decisions that occur in planning a workshop. For instance, the decisions about the methods used in the workshop will impact the artifacts created by the workshop.

Workshop initialization

Workshop initialization broadly covers the decision to use a workshop, workshop constraints, logistics, and participants.

Identify the workshop purpose.

Workshops are a flexible method, but they should be used for a specific purpose within a project. Understanding and articulating the desired workshop purpose will help in designing it and increase the likelihood of success (see sec:workshop-experience for a discussion of the different workshop purposes)

Recommendation: identify the workshop focus based on the current state of the project

- Identifying a workshop focus helps make decisions about designing the workshop which will cascade into the workshop, its outcomes, and influence on the project.
- *Characterization workshops* are used to establish a broad understanding of domain. They usually involve a broad range of domain collaborators, not necessarily *just* frontline analysts [graffinity, updb].
- *Requirements workshops* are used to elicit requirements for a specific analysis problem or dataset. They usually involve frontline analysts [eon, cp, htva, graffinity, lineage].
- See: Section on workshop focus.

Recommendation: identify a workshop goal that is mutually beneficial for visualization designers and collaborators.

- All our workshops had specific goals for the project and collaborators (see table above).
- Workshop goals influence decisions in assembling the workshop.
- Vis: applied visualization research generally focuses on mutually beneficial outcomes where vis researchers find interesting research problems and collaborators gain new tools or knowledge about their data and analysis. The mutually beneficial nature of vis research permeates all workshops used in vis design: every workshop, to some extent, should reflect this. This is in contrast to traditional workshops that focus more on *client's* outcomes [Hamilton2016].

Recommendation: domain collaborators provide guidance while planning workshops

- [arbor] involved a fellow tool builder to review vocabulary before the workshop. This tool builder also helped with piloting workshop methods. Specifically, we tried a few different Wishful Thinking prompts to see which ones could generate the most interesting answers. Collaborators can give insight to participant preference: the [cp] collaborator helped decide on the methods in that he believed the storyboarding method would be better than a proposed alternative.
- Involving collaborators in workshop planning also prepares them for the execution and analysis stages. [cp] collaborator involved in planning also co-facilitated in the workshop. He got involved in small group discussions as he knew the participants, jargon and technical knowledge. He was responsible for clarifying ideas, grouping post-its into domain specific themes, note taking during the discussions, and photographing the stages and artifacts during the workshop.

- Vis: Involving collaborators can help in *bridging the gap* between vis researchers and collaborators [VanWijk2006].
- See also: domain vocabulary.

Recommendation: do not use workshops to resuscitate doomed projects

- Use workshops in projects that fulfill preconditions of the design study methodology. Workshops act as filter for projects where collaborators may not have enough time to commit to a project [updb]

Constraints help in designing a workshop.

The design space of a workshop is practically unbounded and identifying constraints provides hard boundaries that the workshop must fit within. Just as constraints help visualization designers winnow the possible designs [McKenna2014], identifying constraints winnows the possibilities for a workshop.

Recommendation: identify the organizational constraints that may impact the workshop.

- Organizations may have constraints about leaving premises, sharing data, etc. Respect these in planning the workshop. [htva] had defense data. [lineage] had HIPAA-protected.
- Organizational constraints include funding. Funding influences other constraints, such as duration, venue, availability of food, etc

Consideration: select an appropriate workshop duration

- It typically ranges from half day - two days. Half day workshops can feel rushed. One day seems about right for workshops --- most of ours were one day. Two day workshops can be appropriate if there is travel involved. [arbor] + SJ's exp. This will all depend on collaborator's availability.

Consideration: find the workshop location and venue early

- Workshop location and venue determines who is available to participate in the workshop.
- Ensure there is enough room for participants. [arbor] had to break out into smaller rooms, which made it hard to coordinate activities. [Hamilton2016] recommends that the size of workshop venue scales linearly with participants.
- This can take time as we considered many alternative rooms for the[cp] workshop.
- Ideal venue from creativity literature: neutral, well lit, ample space [Isaksen2000].
- It may be hard to pilot workshops in neutral venues, such as the location of [eon,discoveryjam2016,discoveryjam2017]. See also: reality-based pilots,

Consideration: account for interpersonal relationships of project stakeholders

- Do stakeholders get along socially with each other? [SJ's experience / interview]

Cast characters of the workshop.

The cast of characters are recurring roles that we have identified in workshops. There is a strong convergence between these roles and the roles identified in workshop literature. Refer to the (sec:workshop characters) for details on the character roles.

Recommendation: identify the key stakeholder

- Key stakeholder will integrate the results of the workshop into an applied research project. No stakeholder means the workshop result will likely go unused, hence our failure [updb].
- Vis-specific: the key stakeholder in vis projects is likely the visualization researcher. This is different from creativity workshops where the key stakeholder is more likely the client [Hamilton2016].

Recommendation: recruit a workshop team with a primary facilitator and co-facilitators

- The workshop team will actually run the workshop. The workshop team consists of primary facilitators and co-facilitators. The primary facilitator is usually, but not necessarily, the key stakeholder.
- The primary facilitator leads the workshop. The co-facilitators support the primary.
- The co-facilitators may also be responsible for documenting the workshop, through note taking, photographs, and other forms of documentation. Co-facilitators need to be briefed to record information that is not captured by the workshop artifacts as in [cp].
- Effective co-facilitators include: domain collaborators [cp], vis researchers [lineage], and workshop experts [eon].
- Vis-specific: the workshop team likely need knowledge of visualization to effectively steer discussions and generate insights related to "learn" of the DSM [Sedlmair2012].

Recommendation: the workshop team must know enough domain vocabulary.

- The necessary knowledge of vocabulary for workshop team depends on the workshop type. Characterization workshops require a working vocabulary of the domain data --- at least an understanding of the basics so as to ensure no/limited miscommunication. Requirements workshop facilitators need a general understanding of the relevant analysis tools and broad domain challenges. e.g., in [graffinity], the facilitator asked about specific tools for connectomics analysis in order to generate ideas during the wishful thinking method.
- The amount of time to learn appropriate vocabulary varies. In [cp], we had worked with collaborators for 6 months to learn domain vocabulary and characterize the problem. In [graffinity], we conducted about 10 hours of interviews over 2 months and reviewed relevant literature before preparing a workshop.
- Not knowing domain vocabulary can lead to failure. In the [lineage] workshop, the facilitator was unable to effectively lead discussions because he did not understand the terminology of domain data. Fortunately, a co-facilitator who was more familiar with the domain stepped up to lead discussions.

- The key stakeholder must have workshop vocabulary, even if co-facilitators do not. In [eon] - the main facilitator did not know domain vocabulary, but key stakeholder and co-facilitator (SG) had enough domain knowledge to conclude activities during the workshop and to make sense of results during analysis.
- See also: tailor the workshop, domain collaborators

Identify and recruit participants with many methods.

After identifying the ideal participants, there is a challenge of convincing participants that it will be worthwhile to attend your workshop. Consider how many participants you want to recruit. Typically we have recruited 4 - 20 participants, depending on many factors including the physical space for the workshop, size of collaborator's organization, and workshop type. Here are recommendations about recruiting participants:

Recommendation: identify a reason for participants to attend the workshop

- The participants should benefit, in some way, from the goal of the workshop. This may just be the ability to step back from a problem and *"think about what to think about"* [Nickerson1999] in their domain.
- Example: [graffinity] workshop was looking at finding opportunities for collaboration between vis researchers and neuroscientists. We used the workshop goal to recruit members of the neuroscience lab who were not directly working with us. The workshop became an opportunity for our collaborators to express their needs and concerns.
- Example: [cp] participant feedback - *"[The workshop provided] a good way to stop thinking about technical issues and try to see the big picture"*
- See also: workshop goal.

Recommendation: recruit diverse and creative participants

- Diversity of: role in the organization [graffinity], seniority [graffinity,arbor,cp,edina], technological fluency [arbor,edina], expertise in the domain (e.g., in [cp] selecting for practitioners, solver/modeling language developers or students), type of organization they work for (e.g., in [cp] selecting for a mix of academic and industry researchers), and creativity and openness (e.g., as in survey responses in [cp]).
- Understanding diversity of participants will require interacting with them in some way. We have achieved this successfully with surveys [cp] and interviews [arbor].
- Interacting with participants, such as through interviews, can help researchers to better articulate the workshop goal or workshop plan. For example, [arbor] methods were tailored based on feedback of the participants.
- Vis-specific: identify the cast of characters from the DSM when recruiting participants. [graffinity] - a senior member of the lab (*"champion")* helped us recruit postdocs and grad students. Gatekeepers in the workshop may result in more time with analysts.

Recommendation: avoid poppers.

- [Hamilton2016] recommends no *"poppers"* during the workshop. I.e., anyone who may "*pop-in for a minute"* or *"pop-out for a meeting"* in the middle of the day.
- In [cp], one participant had to leave for a couple of hours. This was awkward as they missed an important part of the workshop. In [graffinity], one workshop team member observed the meeting, but took out their laptop partway through observation. This rippled through the room as other participants started taking out their laptops. This made it hard to maintain focus.

Blur the boundaries between roles of collaborators and researchers.

We identified ideal participants of characterization and requirements workshops as domain collaborators and analysts, but visualization researchers can provide valuable insights as workshop participants. Similarly, domain collaborators can make important contributions to the workshop team.

Recommendation: include visualization researchers as participants

- [edina] and [htva] did this.
- We found it useful in [updb, lineage, cp, e.on] to have vis researchers *participating* in the the workshop. The vis researchers were informally acting as scribes, recording ideas. They also encouraged the domain collaborators to elaborate on idea e.g., by asking *data counseling* [Meyer2017] questions throughout the methods: "*why is that important to you?"*
- [arbor] did this too during methods that focused on creating ideas for specific problems. We had the participants come up with broad topics and visualization designers were involved in parallel prototyping ideas for those problems.
- See also: Section: Workshop Experience

Consideration: recruit a domain specialist for the workshop team

- We invited domain specialists to be a part of the workshop team by helping with the initialization and design. For example, in [cp,arbor] the domain vocabulary was complex, and time was limited, so we recruited a domain specialist to revise the goals, and terminology used throughout the workshop.
- In [e.on,] a domain specialist inadvertently became part of the workshop team when they provided WiFi through their phone to access presentation materials. We believe that this helped the workshop because …

Workshop design

We use the term *design* to express all the connotations that are familiar to visualization researchers --- design involves expressing problems, generating and testing potential ideas, and iterating toward useful solutions. In designing a workshop, we often express a problem in the form of a workshop goal. We generate workshop plans based on previous experience and desired outcomes. We improve workshop plans through test and evaluation. The result of workshop design is a flexible plan that will help us to effectively fulfill the workshop goals.

Flexible workshop plans provide means

There is strong consensus from our experience and workshop literature that the agenda for workshops be articulated in a **workshop plan**, a set of materials and prompts that describe what we plan to do, what materials we need to do it, and what effects we expect it to have.

Recommendation: design a flexible workshop plan tailored to the workshop goal

- The workshop plan provides the means to complete the workshop. Without a structured plan, workshops become meetings. In most of our workshops, we iteratively formulated, tested and improved workshop plans [eon,cp,graffinity,arbor,lineage] in order to design effective workshops. Details about this process are included in the remainder of this section.
- We recognize that testing workshop plans cannot account for all possible outcomes of a workshop and emphasize that some degree of flexibility must be incorporated into the designed plan. The plan needs to be flexible --- because we do not know the exact time required for methods, we recommend flexible plans that can adjust by extending methods or shifting the time for breaks [cp, arbor]. Some hard constraints are unavoidable though, e.g., lunch reservations [cp].
- More details about balancing flexibility and focus are discussed in Workshop Execution.
- See also: section on Example Workshops.

Recommendation: plan to use structured methods

- Structured methods are generally preferred to unstructured for creativity workshops.
- Many critics point out that unconstrained ideation wastes time [Chamorro-Premuzic2015]. Participants in the DiscoveryJam workshop told us that brainstorming was "awkward." Feedback from the [arbor] workshop reported that unstructured methods were perceived as less effective
- For example, consider this generalization of a prompt from [eon] *"suppose you are analyzing [your data] and find [a problem]. Please record what would you like to know? What would you like to see? What would you like to do?"* It has been used to create useful output in many of our workshops [graffinity,cp,lineage, arbor, edina, htva, e.on].

Design workshops for analysis

Design workshops with the end in mind. Workshops are used to generate artifacts that help a key stakeholder achieve a goal. The key stakeholder uses the output to influence their applied research project. While designing a workshop, consider how the output of methods will be analyzed. See also: methods to generate useful artifacts, preserve output, and pilot

Recommendation: select workshop methods to generate useful artifacts

- Workshop methods should be selected, in part, by the artifacts that they produce. Methods should generate artifacts that express the ideas of collaborators. These artifacts will be used to achieve the workshop goal.
- Methods with useful artifacts: methods that output tangible results, such as post-it notes in wishful thinking, create output that can be preserved for later analysis [graffinty,cp,eon]. In

[arbor], we wanted to understand high-level problems faced by the domain, so we used a *clustering* method from the consensus workshop [Stanfield2002] to aggregate specific aspirations into higher-level categories. The categories became the key aims of a grant proposal.

- Methods without useful artifacts: unstructured group discussion, although potentially useful, does not guarantee useful output. We had this experience in [discoveryjam2016] where group discussions were not effectively captured.

Recommendation: plan how to preserve method artifacts

- Workshop artifacts will persist throughout the day. Prepare on how they will be organized or re-used.
- For example, if methods generate ideas on post-it notes or sketches, be prepared to capture, to organize, and to preserve those artifacts. This was a problem in [graffinity], we had to shift sets of post-it notes onto large pieces of paper to capture groups of related post-it notes.

Design workshops for creativity

There is strong consensus from creativity workshop literature that effective workshops follow a pattern of generating ideas followed by evaluating ideas and selecting the more promising ones for future action.

Recommendation: creativity guidelines prime productivity

- There is tremendous support for this idea from the creativity workshop literature [Osborn1953,Gordon1961,deBono1983]

Recommendation: introductions can cultivate creativity

- Introduction methods are a valuable tool for encouraging creative thinking. Effective introduction activities support interpersonal leveling by celebrating vulnerability. Even in the case where teams work together regularly, the introduction method provides an opportunity for participants to get to know the workshop team.
- Examples include the *introduce yourself as a plant or animal.* From the [eon] paper: *"The animal introductions required some audacity on the part of our facilitator...it seemed useful preparation for future exercises in initially putting all participants on an equal footing, establishing trust and involving surprise"*
- In [graffinity] participants remarked on the effectiveness of interpersonal leveling introduced through the ice-breaker method and encouraged throughout the workshop: *“the interpersonal leveling and intense re-visiting of concepts made more team progress in a day than we make in a year of lab meetings.”*

Recommendation: use active and divergent methods to explore ideas

- Methods used at the start influence the entire workshop. Using methods that provide agency (e.g., through externalizing ideas) can have a positive impact on the quantity of ideas generated.

- Consider the continuum of creativity - paradigm preserving, paradigm bending, paradigm breaking [McFadzean1998] as connected to wishful thinking, barrier removal.
- Active methods involve generating ideas either individually or in groups. Examples) wishful thinking or current challenges.
- In the Arbor workshop, we started by reviewing the state of the project, which was difficult to facilitate because participants wanted to voice their ideas. [discoveryjam2016] started with lectures, dampening participant excitement.
- See also: introduction method

Recommendation: encourage creativity by connecting methods

- Output from one method becomed input to another. E.g., aspirations -> constraints -> constraint removal in [cp,graffinity,eon]. Similarly, aspirations -> clusters -> springboards as in [arbor] and common in synectics methodology [Gordon1961].
- But this is not universally used as connections are sometimes implicit --- e.g., the storyboarding method in [cp,graffinity,e.on] connected methods by asking participants to synthesize the ideas from earlier in the workshop.

Recommendation: use convergent methods to evaluate ideas

- While generative methods encourage participants to explore ideas, convergent methods encourage participants to winnow their focus to the more interesting ideas. Convergent methods also encourage the synthesis of disparate ideas discussed throughout the day, potentially leading to more creative outcomes.
- At EDINA we ran the "what do you do well..", "what do you NOT do well..", "wSuccessful convergent methods include, for example, *idea clustering* and *storyboarding. Idea Clustering* asks participants to arrange post-it notes into meaningful clusters to identify themes and trends, which can become *springboards* for subsequent methods [Gordon1961]. *Storyboarding* asks participants to synthesize ideas from the workshop and depict, for example in [graffinity], *"a day in the life of a neuroscientist."* We have used it successfully in [eon, cp] as well.
- hat would you really like to be able to do.." (or maybe it was "what would be something you could say that would be an indicator of success.." - the one I remember is "I'd like to put it on my wall") by asking everybody round the table in turn for a an example and then getting people to write as many as they needed to. We then prioritised.
- There is extensive support from the creativity workshop literature on the importance and effectiveness of convergent methods: [CPS2015,Hamilton2016,Osborn1953,Gordon1961].

Recommendation: use downtime to let people communicate and incubate ideas

- Scheduled downtime is not only welcomed by participants, it may be critically important to fostering creativity. More specifically, allowing time for individuals to incubate ideas both consciously and unconsciously is an important part of creative thinking [Sawyer2006].
- In our experience, [eon] and [graffinity] both received strong positive feedback on the use scheduled breaks with ample food and refreshment provided.
- For example, the E.ON lunch was fantastic.

Recommendation: provide closure with a conclusion

- Last impression on the workshop may influence collaboration [Hamilton2016].
- More interesting ideas happen later in the day [?]
- Encourage metacognition through activities that encourage participants to think about how their perceptions may have changed.
- [abor] identified who would take lead of writing the grant.

Consideration: identify the duration of diverge-converge cycles.

- Many cycles in the workshop: [arbor, edina,htva] vs one large cycle in the workshop: [eon, cp,graffinity].
- Discussions can provide some convergence, even if methods do not [graffinity, eon].

Consideration: plan ample time for workshop methods

- Methods should provide time to reach exhaustion of ideas. But, there may be a need to keep moving through ideas. This requires balance.
- Typically use 1 - 2 hours for workshop methods.

Plan with a plethora of resources

We used many resources to prepare, design, and execute our workshop. Look to these resources for inspiration about possible methods and thinking tools to evaluate potential methods.

Recommendation: select methods from existing resources.

- Resources from design: Thinkertoys, etc.
- Resources from creativity: Synectics and creative problem solving
- Resources from visualization: our previous workshops and the section on example workshops.

Recommendation: invent your own methods.

Recommendation: evaluate methods as creativity support tools

- It is useful to evaluate methods before including them in the workshop plan. In addition to evaluating methods based on their output (see design for output), criteria for evaluating *creativity support tools* [Shneiderman2006] provides useful characteristics to consider, including: low barriers, high ceilings, and wide walls; support many paths and many styles
- An example method that we rejected from the plan: In [eon], we considered a method that involved putting post-it note ideas on a drawing of a tree --- to identify opportunities as low hanging fruit. But we had to discuss the location too much -- some may think it easy, others not. We believe this would have hindered creativity as ideas would need to fit into the known structure of a tree.

Consideration: select methods for balance and variety

- Consider analytical frameworks like [Biskjaer2017] or [McKenna2014] - use a variety of active/passive methods; generative evaluative methods; variety of creativity triggers such as metaphor and analogy.
- Balance positive/negative ideation: include methods that ask participants for successes as well as failures about their current work.
- Balance for ideation and discussion: provide adequate time for participants time to work on their own and for sharing ideas in the group, both are important for creativity. Also, consider different ways of sharing ideas, e.g., in partners, in small groups, or in large groups. This will vary depending on the experience and comfort of facilitator, the methods being used, and the size of the group.

Make visualization-specific methods

Methods should account for some of the nuances of visualization design, including the use of real data early in the design process.

Recommendation: incorporate real data in methods

- The Wishful Thinking method of the [arbor] and [graffinity] workshops were tailored to the specific domain. We even used screenshots of current tools to elicit aspirations. The tools were all showing real data being used for real analysis by collaborators. These screenshots were used to push people past exhaustion.
- The [htva] project spent considerable time identifying a surrogate dataset when the real data could not be shared.

Consideration: encourage communication of problems, not solutions

- This is one of the more challenging parts about eliciting requirements during visualization design [Sedlmair2012].

Visualization awareness excites and engages

Visualization awareness serves many roles in creativity workshops. It is an opportunities for the workshop team to show the potential of visualization from a variety of domains. It allows participants to specify “requirements by example” [edina]. And it serves as a passive method, potentially supporting *incubation* of ideas from earlier methods.

Recommendation: select visualizations to engage collaborators.

- Visualizations should be approachable. Not necessarily domain-specific. Example failure: ABySS explorer had data that was too complicated [graffinity].
- [arbor] had MM and AL demo existing visualizations. You will be more confident talking about them. And they help establish credibility with collaborators. But still rehearse them.

Recommendation: encourage analogical thinking during vis awareness.

- "Requirements by example" in [edina]. Analogical reasoning in [cp, graffinity, eon]. Ex) An interesting discussion about neural circuitry resulted from presenting the poemage to neuroscientists: *what does it mean for neurons to rhyme?* Other examples include: *What does it mean for legends to move? [edina] What does it mean for energy to flow? [e.on]*

Recommendation: use materials to preserve visualization awareness ideas

- Provide materials to structure the ideas generated during visualization. For example, [cp,graffinity,arbor] had a idea sheet so everyone could wrote down analogies for each presentation. [Graffinity,arbor,e.on] had screenshots of the demos printed in full color to make it easier to markup.
- The materials helped participants to structure ideas. It also supported analyzing the ideas after the workshop.

Consideration: experiment with visualization awareness structure

- There are many effective ways to run visualization awareness. [eon,cp] presented a series of visualizations while participants wrote down ideas, then discussed as a group. In [cp], for example, these presentations ranged from fast (30seconds - 1 min) and others were longer (4 - 5 min). Group discussion followed.
- [graffinity,arbor] interweaved visualization presentations, idea generation and group discussion. In these workshops, the structure was longer presentation of visualizations (~4 minutes) followed by extensive discussion (~6 minutes)
- The most effective way to structure visualization awareness depends on comfort of facilitator, visualizations being presented, the group dynamics, among other things.

Improve the plan with pilot workshops

We're using *pilot* to mean *test* and we advocate for piloting workshops early and often with varying degrees of fidelity. Early on in designing a workshop, we pilot workshops to test that methods are easy to understand, that they elicit appropriate artifacts, and that they are clearly explained. Closer to the real workshop, piloting will establish expectations of the workshop team.

Recommendation: pilot workshops to test the prompts, materials, and venue

- Pilot methods early on, especially when structuring the workshop. [arbor, lineage] found it useful to anticipate what participants would respond to prompts, and used that more narrowly define a focus.
- Pilot with the prompts that the methods will use. This helps find errors in the prompts, limiting distractions during the day. [Many errors found in graffinity prompts]. Include proxy participants such as other vis researchers or domain collaborators to pilot workshops. [eon] found it useful to pilot methods with vis researchers who had not been involved in workshop design.

- Materials with the wrong affordances will make it more difficult to follow a plan. For example, post-it notes that have space to write more than one idea will make it harder to organize ideas later in the day. Failure [graffinity]
- It is not always possible to pilot in the venue though. Try to closely match the venue, but realize that you will need backup plans. Considerations of the venue include: projector, access to wifi, space for breakouts, and furniture. See also: balance focus with flexibility, workshop plan, and be flexible.

Recommendation: pilot to prepare the team.

- Piloting the workshop with the team helps to elicit feedback on methods and prompts while also clearly communicating expectations for the workshop team.
- In [graffinity] and [arbor], we shared the workshop plan along with the designated roles of the workshop team in each method. For example, in [arbor] we explicitly identified who would facilitate or take notes for each method.
- In [cp], we did not communicate the expectations of co-facilitators, resulting in less than ideal documentation of methods. We believe that piloting the workshop could have helped communicate expectations and would have resulted in more complete documentation.

Workshop execution

Insights about workshop execution relate to the time before a workshop, running the workshop, and the time directly after the workshop. We avoid crisply defining a boundary between execution and other stages, but offer the following heuristic: insights related to execution generally relate to activities after the workshop plan has been finalized, the running of the workshop, and time after the workshop on the day it is completed.

Prime the participants and the workshop team.

Be clear about what you are planning to do with participants.

Recommendation: prepare the workshop team with facilitation resources

- This is meant to complement resources that describe facilitation principles [Hamilton2016], [CPS2015], [Brooks-Harris1999].

Recommendation: communicate the plan with the workshop participants.

- Sharing the workshop plan with participants helps to foster trust and potentially encourages creativity. We received positive feedback from [graffinity] participants that they liked knowing the day workshop would consist of highly structured methods. In contrast, participants in subsequent workshops commented that they would like more detail about just how structured the workshop was going to be [arbor, cp]. We believe that communicating the agenda allows participants to show up focused on the workshop goal instead of fretting over whether their time will be well-spent.

Consideration: assign participant homework to encourage preparation and incubation

- This relates to the four stage model of creativity (see: related work) --- participants may need time to cogitate about their challenges before attending the workshop.
- Prepare for participants to do homework (or not). Participants might like the idea of preparing for the workshop [graffinity]. But, they may also find the homework unnecessary. In [eon], for example, the participant's group leader decided that the homework was not needed because the participants already thought creatively about their problems in daily work [eon].
- Consider how to make use of limited time: can participants prepare something for the first activity? This may be useful if participants cannot commit to a long workshop.
- See also: recruit participants

Foster a creative atmosphere.

On the day of workshop, optimize the venue to a foster a creative atmosphere. At this point, there may be aspects of the venue beyond control. But changing what is possible has potential to make a large difference.

Recommendation: arrive early to arrange furniture

- Furniture should be arranged so that it is conducive to a creative atmosphere and supports interpersonal leveling [Isaksen2000]. [DiscoveryJam2016] could not do this effectively. We think that it hurt the workshop to have a speaker up on the stage in front of the audience. This set an expectation that the audience would be passive. [DiscoveryJam2017], in contrast, had the room arranged in sets of tables conducive to group work. Workshop literature provides some guidance here. For example, avoid elevating speakers above the participants [Hamilton2016].
- See also: location and venue

Balance focus with flexibility.

Collaborators like to expound ideas in workshops. This creates a challenge because not all ideas should be expounded during the workshop---some are outside of the scope or too detailed. Facilitators need to be aware of this.

Recommendation: encourage participants to establish a creative mindset

- Encourage participants to show up well-rested and ready to focus on the day. Sawyer [2006] recommends being able to work for extended periods of time with few distractions.
- See also: bemoan distractions and recruit participants.

Recommendation: guide the workshop

- Facilitators must guide participants through the workshop methods.
- We received feedback from [graffinity] workshop: *"we had a tendency to get distracted."* Internalizing this feedback to more effectively facilitate resulted in more positive feedback from the [arbor] workshop: *"I felt we were guided and kept from going too far off track despite our*

tendencies to do so. This was very effective." and *"[the facilitator] did a great job keeping us on track. There probably would have been large swaths of time wasted on rabbit holes if he did not intervene and keep us going."*

Recommendation: follow the plan, but be flexible.

- Story about defense analysts taking over the workshop [htva].
- Keep moving through the methods, but realize that discussions of interesting topics should be permitted. This must be learned through experience: **"***let ideas, not agenda, drive the day"* [Maiden2004].

Recommendation: lead by example

- Prepare example responses for workshop methods. Example responses should be carefully thought through and aim to inspire participants to generate their own responses.
- This is particularly important for introduction methods --- these may seem silly, but participant feedback consistently says this kind of method is useful to establish creative atmosphere and support interpersonal leveling [graffinity, cp, eon, discoveryjam2017]. It is important to start these methods with example responses from the facilitators and (possibly) the workshop team.
- See also: bemoan distractions.

Recommendation: avoid time sinks - concentrate on problems, not solutions.

- [cp] - SG said that she had difficulty with this because participants were more technical and development oriented.
- This is a challenge of design studies in-general [Sedlmair2010].

Recommendation: encourage diverse interactions between participants and the workshop team

- Facilitators should design partners/groups for methods based on a variety of factors. We have had success mixing up people by organization (VIS person vs. domain specialist), seniority, and gender. This may depend on the goal of the method though.
- Another factor to split-up groups is *interest.* In [discoveryjam] we initially divided into groups based to diversely sample specialty --- each group consisted of someone from each of the three VIS tracks. In contrast, we used similar interests to group participants in [arbor].

Bemoan distractions.

Workshops provide an opportunity to think deeply about the ideas of a project. Distractions, both digital and physical, detract from the experience. The facilitator is responsible for minimizing distraction.

Recommendation: restrict devices (laptops, cell phones, etc)

- Devices introduce distractions from the workshop. This makes it hard to engage participants. Plan to restrict devices and lead by example.
- [graffinity] - co-facilitators had laptops out during the workshop. This was a distraction. It encouraged participants to take out their laptops.

Execute with effective analysis in mind.

Recommendation: preserve output as it is all likely valuable.

- Preserve output and be prepared to gether it after the workshop. This is something we do consistently in all workshops.
- Even when a method fails to produce useful output, the output is important in that it demonstrates a failed method or perhaps the omission of some potentially important (and presumably desirable) information.
- Also, document order if it is needed - e.g. photos of post-its during phases of the activity - this helped see how ideas developed and moved forward.
- See also: methods to generate useful artifacts, preserve output, and pilot

Recommendation: consider tradeoffs of recording with audio or video.

- [lineage] workshop had good experience doing this. We recorded the small group discussions when it was not feasible for the facilitator to be in every group. However, the audio only captured the conversation of one pair of participants.
- [eon:evaluation] used recordings to free the facilitators --- without needing to take notes we could focus on the discussion, though we ended up taking notes anyway.
- There is a potential danger in that audio/video recording can reduce the creativity of individuals [SG said this came up in discussions with SJ re: E.ON].
- Also, making transcripts from audio and video is generally time consuming [LLoyd2011].

Gather feedback to evaluate and improve workshops.

Feedback from participants can help identify important ideas from the day. It can also help to improve methods and ideas for future workshops. What does a good post-workshop survey look like?

Recommendation: use online surveys to gather participant feedback.

- We have had success gathering feedback from workshop participants through online surveys. Generally, surveys were prepared before the workshop and sent to participants within one or two days after completing the workshop [graffinity, arbor, cp]. Also, ask for feedback repeatedly -- people will ignore e-mail surveys the first time [arbor, graffinity].
- Feedback provided insights on the perceived efficacy of workshop methods.
- Co-design research suggested that “fun” feedback media, such as postcards, could be useful for gathering feedback from participants [Dove2013]. But we had limited success using postcards for feedback [eon].
- Example method and feedback that it received: storyboarding received mixed feedback from [graffinity, e.on] because, we think, participants did not feel comfortable ideas into a story. Though in subsequent workshops, storyboarding in pairs worked well [cp].
- See also: example workshops - for a sample survey used to gather feedback.

Recommendation: reflect on workshop efficacy with the workshop team

- Evaluate the experience with the team within one or two days of completing the workshop.
- [eon] did this to talk about how things went, what went well (or not), what could be done better etc. Took about 30 minutes.
- Reflection on [discoveryjam2016] revealed: 1) the half day workshop was too short, we needed a full day and; 2) the speakers at the start of the workshop discouraged participation. We changed this in [discoveryjam2017].

Workshop analysis

Analyzing workshop output results in actionable knowledge that influences the visualization design process in ways that are both profound and subtle. But the process of analyzing output often requires more time than is spent in the workshop. In fact, even as we gain experience running a variety of workshops, we consistently *underestimate* the tremendous time required to think deeply about the workshop output which is typically on the order of tens of hours spread over days or weeks. During that time, we have used methods that range from informally reading, thinking and discussing workshop output to more formal methods of coding and aggregating output. Here, we describe the insights related to the process of analyzing workshop results. (See also: Plan to analyze method output, preserve output, pilot).

Workshops deluge with data and artifacts.

Workshops produce a tremendous amount of data and artifacts. Hundreds of post-it notes. Tens of sketches. Hours of transcripts. Making sense of the output is labor intensive. Prepare for this.

Recommendation: the key stakeholder must drive the time-consuming analysis.

- Making sense of a workshop output is a tremendous amount of work, often requiring days of careful thought and reflection. It is critically important that a key stakeholder understands their responsibility to analyze workshop output --- *without their time and energy, the workshop output will likely go unused* [updb].

Recommendation: the workshop team and other stakeholders may help with analysis

- The key stakeholder may need help analyzing the output from the workshop team, potentially involving visualization researchers and domain collaborators. In [graffinity], a domain collaborator helped us understand some of the abbreviations and jargon in the workshop output.

Recommendation: schedule time to analyze workshop output

- Although the exact time needed to analyze workshop output depends on many factors, we have found a minimum of at least half a day is required for analysis. Scheduling this analysis time in advance of the workshop guarantees that the key stakeholder will be able to think deeply about workshop output.

- We discourage entirely analyzing output on the same day as the workshop execution to avoid fatigue and allow for incubation of ideas. We started the analysis of most workshops within 24 hours of executing it [graffinity,updb,lienage,arbor,cp?,eon?]

Analyze workshops to achieve the goal.

Just as the workshop methods will vary by goal, so too will the analysis methods. More specifically, the outcomes of analysis methods should move the key stakeholder and other project stakeholders toward the *workshop goal* which is often connected to the *project goal.* The analysis methods should be selected to achieve this.

Recommendation: identify the purpose of workshop analysis.

- The purpose of workshop analysis relates closely to the workshop goal and project goal.
- In [graffinty] the project goal *"Explore opportunities for multivariate graph visualization"* which is reflected in the workshop goal *"Find opportunities for visualization in retinal connectomics and identify shared user needs."* To analyze the output, we aggregated individual ideas into broad visualization opportunities to find interesting visualization problems and ultimately focused on the shared need and open visualization problem of analyzing graph connectivity.
- In [cp] the project goal was to *"Design performance profiling methods for constraint programmers"* while the workshop goal looked at finding specific problems in that domain. We relied on aggregation into key themes and tasks to articulate specific visualization problems, which we then evaluated and explored in more depth.
- See also: methods to generate useful artifacts, preserve output, and pilot

Recommendation: analyze workshop output with qualitative methods

- The workshop data and artifacts are diverse and full of descriptive, important details. Analysis methods should celebrate the diversity and details of output. Qualitative analysis seems most effective for that.
- Example: [lineage] used a mind-map/affinity diagram to relate artifacts into meaningful tasks. These meaningful tasks later became design requirements.
- Failure example: In [graffinity], we tried to analyze themes of workshop output quantitatively, by counting the ideas related to certain themes. But this failed to provide meaningful insights as the frequency of ideas says little about their importance. For example, important ideas may emerge from discussions and not be recorded on any artifacts.

Recommendation: quantitative analysis may also be interesting

- [eon and cp] tracked how themes developed throughout the day. This provided an overview of the spread of themes during the day, to see how they change through specific methods.
- Quantifying the number of themes while also describing them, helped to evaluate the choice of methods used in the workshop. For example) wishful thinking contributed a large number of futuristic ideas [cp].

- Quantifying method output is commonly used for evaluating methods in creativity workshops in other domains [Dove2015].

Workshops influence projects in profound and subtle ways.

The knowledge and experience gained through workshops has profound and subtle influences on applied visualization research projects. The insights from workshops are potentially useful throughout the design process. Just as there are no *correct* ways to use the results of interviews, there are also no *correct* ways to use workshop insights. However, some ideas for how to use workshops insights and future projects can be gleaned from analyzing how we have used it.

Recommendation: complement workshops with traditional user-centered design methods

- The workshop provides a broad overview and areas of it can be filled in with more narrowly scoped methods. [graffinity] exposed a shared goal of analyzing neural networks connectivity. Following the workshop, we performed contextual inquiry to better understand the low-level tasks associated with this goal.

Recommendation: workshops provide value for generative and evaluative design methods

- Workshop insights can be explored in more detail with generative design methods, generative design methods expand the space of ideas for possible designs [McKenna2014]. Workshop insights provide criteria that can be used with evaluative design methods, methods that winnow the space of ideas for possible designs [McKenna2014].
- Examples of generative methods: include the parallel prototyping that followed workshops in the HTVA and EDINA projects.
- Examples of evaluative methods: *"everything in three clicks"* from [eon]. And the *"access to underlying database keys"* from [graffinity].

Recommendation*:* workshops can guide additional workshops.

- The E.ON project used the output of a requirements workshop as input to a design workshop focused on creating prototype visualizations. Additional workshops were used to gather feedback on and ultimately evaluate ideas.
- See also: (sec: workshop focus).

Recommendation: workshops provide provenance of design decisions.

- Designers in the E.ON project used the output from a series of workshops to build a story about how a design was developed. This included the design's motivation from the requirements workshop [eon], her actions during the design workshop [eon:design], and initial collaborator feedback during [eon:feedback].
- Quote from participant: *"Presenting, taking feedback and coming back with new stuff and also reminding us of your feedback was, was very helpful. I thought that was really good."*
- [cp] used workshop output to summarize next steps for the domain. [arbor] was used to write a grant. All projects referred to workshops in publications.

Hedging the insights, recommendations and considerations.

The analytical constructs, insights, recommendations and considerations in this section our experience, but we recognize that they are not an exhaustive description of possibilities. This paper is meant to be a starting point for planning, using, and analyzing creativity workshops in applied visualization research. We hope that the visualization community will continue exploring the use of creativity workshops and either validate or refute our claims.

Example workshops

We need to fill this in.

Discussion

The discussion will hedge some of our claims and contributions. It will also identify cases where workshops may not be appropriate.

Limitations of reflection

The reflection focuses on describing our experience. We recognize it is one possible interpretation of what happened in workshops. Other researchers may reach different conclusions. We are not trying to claim predictive validity

Future work

We need to think about what recommendations and insights apply to workshops later in the design process. We also need to think about whether our 4 stage framework is useful for design and evaluation workshops.

We would like to think a little about how we can use creativity in evaluation too - pushing people to perform tasks and test software in ways that involve creative thinking. This is similar to the Creativity Support Tools work of [Shneiderman2006].

Not sure if/where to include this stuff

These are some ideas that I'm not sure belong in the paper. We'll need to revisit them.

Compare our work to other workshop frameworks

Connect workshop focus to related work. The workshop focus maps to different types of workshops identified in the commonly used Creative Problem Solving Methodology [CPS2015]. Domain

Characterization and Requirements workshops generally fit into the *Clarify* and *Ideate* stages of CPS. In Domain Characterization and Requirements, we generally focus on learning about the domain by eliciting thoughts from participants. This includes *Exploring the Vision, Gathering Data, Formulating Challenges, and Exploring Ideas.* The Design workshop is similar to the *Implement* stage of CPS as we actively explore solutions to the earlier ideas. The Evaluate-focused workshops are not necessarily described by the CPS methodology.

Compare workshops to other methods

Comparing workshops to other methods used by designers wades into a space of nebulous and often overloaded definitions at the intersection of ethnography, design, human-computer interaction and business. We focus our discussion on related methods that (1) involve direct contact with stakeholders and (2) have been reported as common techniques by more than one visualization design process or decision model [Munzner2009,Sedlmair2012,McKenna2014,Roberts2017,Goodwin2012,Koh2011]. We characterize related methods by the intended flow of information between designers and project stakeholders.

Methods that typically encourage a one-way flow of information from stakeholders to designer. Designers use these methods to gather information. (Though the designer may inadvertently share information in two-ways---for example, through leading questions in an interview.)

Interviews are *"fundamental research method for direct contact with participants, to collect firsthand personal accounts of experience, opinions, attitudes, and perceptions."* [Hanington2012]

- Typically 1:1, but can also be 1:many as in focus groups. Range on a spectrum of unstructured, semi-structured, structured [Bernard2011]
- Strengths: Interviews help to establish rapport with stakeholders [Bernard2011] and to provide an understanding of how stakeholders perceive their experience. They can also be used to understand emotions about a topic [Hogan2016]. Interviews are incredibly flexible and fulfill many roles in the design process.
- Weaknesses: interviews require practice to effectively execute [Bernard2011]. Based on our own experience, they can be time consuming, they provide a piecemeal understanding stakeholder perspectives, and they require many sessions to completely explore topics.

Interviews suffer from the paradox of tacit knowledge --- we know more than we can say.

Observation / fly-on-the-wall Emphasizes passive, silent and unobtrusive observation of participants in their environment [Blomberg1983].

- Typically 1:1 and occur in the place where stakeholders work.
- Weaknesses: Generally seen as not sufficient for understanding the needs of users because thoughts are not necessarily expressed in actions [Sedlmair2012]

Contextual inquiry [Holtzblatt1993]

- Based on the assumption that we know more than we can say. Strong ecological validity as work is investigated in the context where it occurs.
- Like interviews, contextual inquiry is typically 1:1 and can also be 1:many. It emphasizes a one-way flow of information from the participant to the enquirer.

Methods that typically encourage a two-way flow of information between designers and stakeholders. Designers use these methods to exchange information with stakeholders.

Meetings

- *"The act or process of coming together for discussion or entertainment"* [Merriam-Webster]
- Provide a forum for *group communication* with different goals ranging from *informative-digestive, constructive-originate, and executive responsibilities* [Jay1976]
- There is no connotation that meetings will achieve a goal, they may just be to communicate ideas.
- Process models emphasize that meetings may be useful to winnow the set of collaborators, but do not comment on their effectiveness in the design process [Sedlmair2012].
- We characterize 1:1, many:many, and many:1, discussions as meetings too.

Workshops

- *"a meeting at which a group of people engage in intensive discussion and activity on a particular subject or project."* [Merriam-Webster]
- Workshops typically use structured participatory methods to achieve a specific goal. [Brooks-Harris1999]

Creativity workshops

- A workshop that emphasizes creativity in the form of creating new and useful ideas. Creativity is often encouraged through cycles of divergent and convergent thinking, suspending judgement, or reformulating ideas [Osborn1953].
- Just as all methods used in design are creativity methods to some extent [Biskjaer2017], all workshops used in design are creativity workshops. The key distinguishing feature of creativity workshops is the **intent** of the individuals using the workshop.