Outline

Introduction

We are talking about creativity workshops for applied visualization research. We call them visualization creativity workshops or “workshops” in this paper.

Creativity workshops are a flexible method, complementing existing methods and methodologies. Benefits of using creativity workshops in applied projects includes:

- Generating artifacts that express the needs, concerns, and opinions of collaborators regarding broad domain challenges and specific analysis needs. This relates to predesign empiricism [Brehmer2016] and evaluation of the needs of users (from seven guiding scenarios) [Lam2012].
- Providing time to *“think about what to think about”* [Nickerson1999], allowing for evolution of ideas in a focused setting and accelerating the *understand* activity of DAF [McKenna2014].
- Establishing consensus from seemingly diverse user needs, a common problem when designing visualizations for expert users in large organizations [Sedlmair2010].

- Generating potential transformative insights:
    - *"We found conducting the imagination exercises highly valuable in the context where opportunities offered by information visualization can allow radically different approached to legend construction and use"* - [EDINA]
    - *"there is stuff in here that we cannot do, or haven't thought about needing to do but potentially should be doing or just don't know how to do it"* - [*HTVA] participants*
- Establishing buy-in from collaborators
    - *"Stimulating for how [visualization] ideas might be useful in my work"* - [CP] feedback

Overall, creativity workshops provide an opportunity to achieve plenty, learn lots, and build relationships.

Although there is extensive literature about workshops from other domains, that literature does not necessarily apply to visualization research. Some key difference of visualization research includes:

- Incorporating data early and often in the visualization design process
    - Data is mentioned only implicitly in workshops used in other domains [SJ interview]
    - Visualization design generally recognizes importance of data early in the design process: *"what do the data want to be?"* [Pretorious]
- Emphasizing knowledge transfer between visualization designers and collaborators
    - Creativity workshops generally focus on achieving a goal for clients [Gordon1961] or empowering individuals to solve their own problems [Hamilton2016].
    - Visualization designers need to "bridge the gap" [VanWijk2006] of knowledge.
- Using existing visualization process and decision models
    - Integrate existing theoretical research [Sedlmair2012,Munzner2009,McKenna2014]

There is little existing guidance for visualization creativity workshops.

Contributions

Through **critically reflective practice**, we propose an actionable framework for visualization creativity workshops. The **visualization creativity workshop framework**:

- Identifies 4 distinct **workshop focuses,** characterizing workshops in process and decision models
- Proposes **20 actionable insights** transferrable to future workshops. Insights are categorized into:
    - preparing for a workshop,
    - selecting workshop methods,
    - running the workshop, and
    - analyzing + acting on workshop results
- Each insight is supported with:
    - Recommendations - ideas and actions that are likely beneficial
    - Considerations - ideas and actions that should be taken into account
    - Open questions - ideas and actions that need additional research
- Provide **example workshop** plans --- starting points for visualization researchers to apply creativity workshops to their own projects.

Related work

Included in this section are: 1) a definition of creativity and creativity workshops, 2) a background of creativity and creativity workshops for problem solving and software engineering, 3) a summary of workshops in visualization.

We adopt a definition of creativity based on 4 characteristics:

- Creativity is the generation of new and useful ideas [Mayer1999,...]
- Creativity in psychology: hard work, open communication, series of mini-insights [Sawyer2006]
- Creativity in design and problem solving: divergence-convergence [CPS, Lowgren1995,...]
- Group creativity results from synergy between group members [Sawyer2003]

There are many definitions of creativity workshops. They all involve some criteria: group participation, creativity, focus on a goal. We adopt the following definitions in this paper:

- **Methods** are the repeatable procedures that describe actions of designers [Crotty1998]
- **Creativity methods** are methods that encourage creativity --- to some extent all design methods are creativity methods because of the creative nature of design [Biskjaer2017]
- **Workshops** are the structured use of methods to achieve a goal.
- **Creativity workshops** are the structured use of creativity methods to achieve a goal.

The distinction between **creativity workshops** and **workshops** is often based on intent rather than observable differences [Hamilton2016].

Creativity and creativity workshops: a brief history

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.

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 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

~~Using structured workshops has evolved in visualization from origins in~~ Workshops in visualization are ~~human-computer interaction and geographic information systems~~ participatory and user-centered methods. ~~[Dykes2010].~~ Koh et al.[Koh2011] describe a process where two workshops demonstrate visualizations to collaborators: *visualization awareness workshops* show collaborators generic visualizations to elicit requirements by example and *domain visualization workshops* demonstrate visualization prototypes with collaborators' real data. Similarly, 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 show that workshops are useful in applied visualization research, but fall short of prescribing guidelines or specific methods.

Workshops in visualization design also evolved from the fields of software engineering and creative problem solving as Goodwin et al [Goodwin2013] used three workshops in a design study with energy

analysts. This work inspired our use of creativity workshops in a variety of additional projects [Goodwin2016,Kerzner2017,Kerzner2017:UPDB,Lisle2017,Nobre2017,Rogers2016], described in more detail in the next sections.

Workshop focus

Visualization process and decision models describe the actions of researchers. We can use such models to characterize workshops based on their intended role in the visualization design process. We call this the **workshop focus**.

The different types of workshop focus are 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

Hedge the workshop focus

Workshop focus abstracts the intended outcome of complex activities and interactions. It is impossible to perfectly describe the outcome of a workshop. In fact, one benefit of workshops is the serendipitous and unpredictable results. The workshop focus is meant to be an abstraction, providing vocabulary for describing our experience.

Winnow the scope of this paper

We are going to examine workshops early on in the design process. More specifically, these are workshops focused on characterization and requirements.

Where did the workshop focus come from?

The four distinct workshop focuses result from the analysis of our experience: 8 projects and a total of 12 workshops.

Connect workshop focus to related work

These workshop focuses feel similar to the CPS methodology. 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 feels similar to the *Implement* stage of CPS as we actively explore solutions to the earlier ideas. It's not clear where the Evaluation fits into to CPS.

Workshop experience

The projects where we've used workshops:

Project name	Author	Domain	Collaborators	Project goal	Num workshops	Reference	Result
EDINA	Dykes	GIS	Industry	*"reimagine the legend in the context of visualization"*	1	[10]	InfoVis paper
E. ON	Goodwin	Energy	Industry	Deliver insights into the role of Smarthomes and new business potenital	3	[12]	InfoVis paper
HTVA	Walker	Human terrain	Defense	*"develop [visualization] techniques that are meaningful in HTA"*	2	[59]	InfoVis paper
CP	Goodwin	Constraint programming	Academic	Design performance profiling methods for constraint programmers	1	[13]	VAST paper
DiscoveryJam	Rogers	Hydrology	Industry	Promote collaboration between visualization researchers and domain scientists	2 (in parallel)	[44]	Vis Workshop
Graffinity	Kerzner	Neuroscience	Academic	Create novel visualization techniques for multivariate graphs	1	[25]	EuroVis paper
Lineage	Nobre	Psychiatry	Academic	Create visualization tools to analyze determining or associated factors of suicide	1	[41]	TVCG paper
UPDB	Kerzner	Genealogy	Academic	Create visualizations to support genealogy analysis	1	[24]	—
Arbor	Lisle	Biology	Academic	Create visualization software for phylogenetic analysis	1	[27]	NSF grant application

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.

The workshops that we've used in each project:

Project name	Workshop goal	Participants	Duration (days)	Workshop focus
EDINA	Explore possibilities for enhancing legends with visualization	7 employees of EDINA GeoSpatial Services	1	Requirements
E. ON	Identify ways of utilising Smart Home data/technologies	5 employees of Forward Thinking Tech. Team	1	Requirements
	Develop concepts from requirements workshop in an agile approach	7 visualization designers	0.5 x 2	Design
	Elicit feedback on prototypes from experts	8 analysts total, 4 from previous workshops	1	Evaluation
HTVA	Establish current practice and perceived needs	4 analysts, 8 visualization designers	1	Requirements
	Acquire feedback on progress and additional requirements	4 defense analysts (?)	1	Evaluation
CP	Identify data analysis and visualization opportunities	10 analysts	1	Requirements
DiscoveryJam	*A game jam for science*	20 - 40 attendees of IEEE Vis.	0.5	Design
Graffinity	Find opportunities for visualization in retinal connectomics and identify shared user needs	9 analysts and support staff	1	Requirements
Lineage	Understand the main domain tasks of collaborators	6 genealogy psychiatric analysts	0.5	Requirements
UPDB	Find opportunities for a design study with genealogy researchers	7 analysts and 3 vis designers	0.5	Domain characterization
Arbor	Find opportunities for funded collaboration between visualization designers and biologists	10 biologists, 2 visualization designers	2	Domain characterization

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.

Research methods

The visualization creativity workshop framework results from 2 years of collaboration between visualization designers and creativity researchers. This collaboration was motivated by the following question: how can we share our experiential knowledge with other visualization designers?

Research Methodology

We approached this through a methodology of **critically reflective practice** [Thompson2008]: "*a process of synthesizing experience, reflection, self-awareness and critical thinking to modify of change approaches to practice."* It also includes: *"an awareness and understanding of complexity."* And it draws on both existing theoretical knowledge about a field and practical experience.

Critically reflective practice is inherently subjective

We recognize our own backgrounds and biases. Co-authors are applied visualization researchers with 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. The analysis reflects our subjective understanding of workshops.

Critically reflective practice is more appropriate than grounded theory for this project because it relies heavily on the tacit knowledge of practitioners. Critically reflective practice is more appropriate than more controlled scientific methods because workshops are used in applied projects where controlled experiments are not feasible.

Research timeline

The research methods of our reflective practice have evolved over our two year collaboration. Analysis and action were intertwined. The timeline of experience and analysis:

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

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.

Reflection-for-action methods

Our reflection-for-action resembles the process of creativity as we have created the framework by combining a series of interconnected mini-insights about our experience [Sawyer2006].

Mini-insight are small insights developed from hard work and can be explained by their context [Sawyer2006]. We recorded 85 mini-insights from conversations, careful analysis of our workshops, the workshop materials and workshop output. Through collaborative qualitative analysis, we aggregated the mini-insights into larger insights.

The ideas of our paper are presented as insights, recommendations and considerations.

Insights provide high-level structure of our ideas. They are *"a holistic understanding of the true nature of something"* [Merriam-Webster2017]. Insights encompass recommendations and considerations.

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. They are *"an idea taken into account for an action"* [Merriam-Webster2017].

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.

Insights also identify open questions. **Open questions** suggest ideas that we find interesting, but lack knowledge or experience to address. These provide interesting opportunities for future research. Open questions may include speculation, based on circumstantial evidence from our experience.

What makes this a *visualization* creativity workshop framework? Our reflection is a subjective interpretation of our experiences. We interpret experiences as visualization designers, so we believe all of the insights generated apply to visualization creativity workshops.

The Visualization Creativity Workshop Framework

The result of our reflection-for-action is articulated into a series of insights that we call the Visualization Creativity Workshop Framework. Insights, recommendations and considerations all have a unique identifier. This is used to cross reference related concepts in the framework.

The insights are organized roughly by the temporal aspects of preparing for a workshop, running a workshop, analyzing the workshop results and acting on the results of that analysis. The first insight provides structure to the process of preparing for a workshop:

Workshops must be *designed*. Workshops must be designed to fulfill specific needs for a research project. Designing a workshop involves expressing a problem --- identifying the workshop purpose and constraints. Proposing a solution in the form of a planned workshop. Testing the workshop one or more times, often in smaller pilots. And finally, using the workshop in the project.

- **Recommendation:** Workshop design consists of two stages: **1) pre-design** identifies the broad goal and constraints. **2) Method design** selects the methods used for the workshop.
    - [Brooks-Harris1999] use the analogy of architecture to describe the process of planning a workshop. Pre-design is like the physical layout of a building --- it is often immutable and constrained by external forces like the building code and budget. Method design is like the interior decoration --- it is flexible and there are many possible alternatives.
    - This is in-line with my experience in [Arbor] and [Lineage] --- I first identified the constraints before planning how to fill up those constraints with a workshop.
- **Recommendation:** workshop decisions cascade through the project
    - Pre-design decisions cascade through the rest of the process. For example, the workshop purpose will affect the choice of participants and workshop methods.
    - See *pilot the workshop.*
- **Recommendation:** allocate time to design a workshop.
    - It takes time to tailor workshops to a specific domain, invite collaborators, gather materials, identify a venue, pilot workshops, etc.

- Vis: taking time to design a workshop relates to pre-design empiricism. It also connects to ideas about empathy and acknowledging the specialties of vis design
- Mini-insights: this results from all mini-insights --- there is a lot to consider.

Workshop pre-design

Workshop pre-design 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.

- **Recommendation:** identify the workshop focus based on the current state of the project
  - See: Section on workshop focus. 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 anlaysis problem or dataset. They usually involve frontline analysts [Lineage, E.ON, CP, HTVA].
- **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: the workshop goal is about mutually beneficial outcomes, whereas traditional workshops focus more on *client's* outcomes [Hamilton2016]
  - Mini-insights: [workshop objects], [workshop goal]
- **Recommendation:** tailor the workshop to the specific project and goal.
  - Avoid ambiguous language e.g., do not use the word "constraint" when working with constraint programmers. Make sure you know enough about the domain to do this.
  - Involve domain experts in planning the workshop as needed. [Arbor] involved a fellow tool builder to review vocabulary before the workshop.
  - Vis: there is respective specialization of collaborators vs designers that may be missing from other workshop models.
  - Mini-insights: [domain knowledge], [plan], [customize methods]

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] [Lineage + HIPAA-protected data]
    - Organizational constraints include funding. Funding influences other constraints, such as duration, venue, availability of food, etc
    - Mini-insights: [constraints]
- **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.
    - Mini-insights: [duration], [constraints]
- **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.
    - Ideal venue from creativity literature: neutral, well lit, ample space [Isaksen2000].
- **Consideration:** consider the stakeholder interpersonal relationships
    - 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.

- **Recommendation:** identify a workshop leader
    - Leader will integrate the results of the workshop into an applied research project. No leader means the workshop result will likely go unused, hence our failure [UPDB].
    - Vis-specific: the *leader* in vis projects is likely the visualization researcher. This is different from creativity workshops where the leader is more likely the client [Hamilton2016].
- **Recommendation:** identify the workshop facilitators
    - Facilitators will actually run the workshop. They work closely with leaders or they may be the leader. Everyone is capable of facilitating workshops, not just professionals [E.ON].
    - Vis-specific: facilitators likely need knowledge of visualization to effectively steer discussions and generate insights related to "learn" of the DSM [Sedlmair2012].
- **Recommendation:** identify workshop scribes
    - Scribes take notes during the workshop. They may be additional facilitators.
    - Scribes need to be briefed to record information that is not captured by the workshop as in [CP].
- **Recommendation:** know the domain vocabulary before designing or running a workshop.
    - Vocabulary is necessary for the facilitators to help lead and follow discussions. [Lineage, potential failure as I tried to facilitate the workshop]
    - Vocabulary is necessary for leader to understand the results of the workshop.

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, and different ways of doing that.

- **Recommendation:** identify the workshop participants.
    - Participants will actually participate in the workshop. For characterization and requirements workshops they are likely domain collaborators and frontline analysts.
- **Consideration:** the number of participants depends on many factors, including physical location, collaborators organization, facilitators experience, and workshop type.
    - Typically we have recruited 4 - 20 participants. See table of our experiences. [Hamilton2016] argues that the number of participants scales with the space available for small groups.
- **Consideration:** invite participants using the workshop goal.
    - The goal articulates the mutually beneficial outcomes that can be expected from it, useful for gathering interest in the workshop.
- **Recommendation:** recruit participants committed to the project and the workshop
    - Avoid "poppers" and "observers" as they distract from the workshop goal. [Hamilton2016] [Graffinity]
- **Recommendation:** recruit diverse and creative participants
    - Diversity of: role in the organization [Graffinity], seniority [Graffinity,Arbor], technological fluency [Arbor], primary interest in the domain [CP]
    - Creativity and openness to exploring ideas as in surveys of [CP]
    - 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.
- **Consideration:** interview participants before the workshop
    - Interviews allow you to understand what participants would like to get out of the workshop. These interviews can be helpful for planning and identifying a goal [Arbor].
- **Open question:** include visualization designers as participants in the workshop
    - [EDINA] and [HTVA] did this.
    - [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.

Workshop design

Workshop design is where we select the methods that will be used in it. The constraints identified during pre-design are useful in winnowing the possible design space.

Well-defined workshop scope allows for openness and exploration. There's a paradox about workshops: participants feel like they are performing entirely open ended methods to explore a problem, but workshops result from careful planning and execution. The methods are structured in a way to narrow on a specific scope while generating ideas. [Quotes from E.ON participants]

- **Recommendation:** create a workshop plan that identifies what you will do during the workshop, how you will do it, and what you will need to do it.
    - Workshop is a large investment for you and your collaborators. An opportunity to impress your collaborators (or disappoint them). Put in time to select appropriate methods, and make sure the methods will be useful.
- **Recommendation:** structured methods help maintain focus.
    - Criticism of brainstorming [Chamorro-Premuzic2015]: unconstrained ideation wastes time. 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.
    - As workshop leaders, structured output is generally easier to analyze because it has a similar format.
- **Recommendation:** create a flexible plan for the workshop
    - Ideas, not agendas should drive the day [SJ's work, Jones2004?]
    - Story about defense analysts taking over the workshop [HTVA]
- **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.
    - Ex) visualization awareness: 10 minutes per visualization resulted from 4 minute presentation and 6 minutes of discussion.
    - Typically use 1 - 2 hours for workshop methods.

Workshop methods generally follow a pattern: diverge then converge. 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:** open ideas gradually.
    - Consider the continuum of creativity - paradigm preserving, paradigm bending, paradigm breaking [McFadzean1998] as connected to wishful thinking, barrier removal.
    - Type of creativity also depends on skill of facilitator and trust of the group [?]
- **Consideration:** identify the duration of diverge-converge cycles.
    - Many cycles in the workshop: [Arbor, vizLegends, HTVA] vs one large cycle in the workshop: [E.ON, CP, Graffinity].
    - Discussions can provide some convergence, even if methods do not [Graffinity].
- **Consideration:** link methods through ideas and artifacts to support diverge-converge cycles
    - Output from one method becomed input to another. E.g., aspirations -> constraints -> constraint removal in [CP, Graffinity, E.ON]. But this is not universally used as connections are sometimes implicit.
    - This is similar to the *springboards* used in Synectics [Gordon1961], and the four stages of the CPS methodology.

Establish a creative atmosphere for open communication and interpersonal leveling. Workshops need to encourage the free exchange of ideas without worry of being criticized. There is strong consensus from the creativity literature that open communication between group members leads to more creative output

[Sawyer2006,2003]. In our experiences, participants remarked on the effectiveness of interpersonal leveling: *"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 an introduction method to start the day.
    - If participants do not know each other, use an ice breaker activity. Good introduction activities support interpersonal leveling by celebrating vulnerability. Examples include the *introduce yourself as a plant or animal.*
    - From the E.ON 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" - E.ON paper.*
- **Recommendation:** encourage participants to suspend judgement
    - There is tremendous support for this idea from the creativity workshop literature [Osborn1953,Gordon1961,deBono1983]

Prime for productivity with generative methods that provide agency. 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.

- **Recommendation:** use active methods early in the day (and avoid passive methods).
    - 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. DiscoveryJam started with lectures, dampening participant excitement.
    - See also: introduction method

Excite and engage participants with the visualization awareness method. Visualization awareness is a method commonly used in the visualization community. It serves to show the potential of visualizations from a variety of domains. It also fulfills a active

- **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, E.ON]. Ex) An interesting discussion about neural circuitry resulted from presenting the poemage to neuroscientists: *what does it mean for neurons to rhyme?*

Provide closure by wrapping up with convergent methods. Use methods that provide closure to participants at the end of the day.

- **Consideration:** the workshop conclusion is important.
    - Last impression on the workshop [Hamilton2016] may influence collaboration.
    - More interesting ideas happen later in the day [?]

    - Encourage metacognition through activities that encourage participants to think about how their perceptions may have changed.
- **Consideration:** provide plans for future action in the conclusion
    - [Arbor] identified who would take lead of writing the grant.

Select methods from extensive resources---or invent your own. There are many resources that describe methods used in creativity workshops.

- **Recommendation:** existing resources for selecting methods come from a variety of domains
    - Resources from design: Thinkertoys, etc.
    - Resources from creativity: Synectics and creative problem solving
    - Resources from visualization: our previous workshops
- **Recommendation:** includes real data in methods of the workshop
    - 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:** critically evaluate potential methods as creativity support tools
    - Criteria for creativity support tools includes: low barriers, high ceilings, and wide walls; support many paths and many styles [Shneiderman2006].
    - Example method that probably did not meet that criteria: storyboarding received mixed feedback from [Graffinity] because, we think, participants did not feel comfortable drawing ideas into a story
- **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.
- **Consideration:** use methods that balance ideation with discussion
    - I prefer methods that allow individuals to generate ideas, then discuss ideas in small groups, and finally discuss ideas in the large group. Each level of discussion usually generates additional ideas.

Pilot workshops with real methods, materials and tools. Running a pilot workshop serves many purposes. 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 facilitators, scribes, and the leader. Piloting also helps identify necessary materials for the workshop.

- **Recommendation:** pilot early and often.

    - We're using *pilot* to mean *test*. Pilot methods early on, especially when structuring the workshop. [Arbor and Lineage] found it useful to anticipate what participants would respond to prompts, and used that more narrowly define a focus.
- **Recommendation:** use reality-based pilots with real methods, materials and venue
    - 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]
    - Multiple workshops have been obstructed by materials that have the wrong affordances. 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]
    - Venue: [E.ON] lacked adequate projector and internet connection for demos.
- **Consideration:** pilot with facilitators, scribes, the leader, and (possibly) collaborators
    - This ensures that all of the workshop support knows their role and what the expectations for the day are. [Failure: CP (?)]
    - Collaborators can be helpful to check correct use of domain-specific language [Arbor]

Running the workshop

There are many guides on how specific details about effectively facilitate workshops. We're going to focus on aspects that are important from our experience in visualization projects. This is meant to complement resources like [Hamilton2016].

Prepare participants for the workshop. Be clear about what you are planning to do with participants.

- **Recommendation:** communicate the plan with participants before the workshop and at the start of the workshop.
    - Graffinity participants liked clear communication about structure. Arbor participants wanted more details about how structured it would be.
    - Speculation: having a focused plan allows participants to feel more free in exploring ideas.
- **Consideration:** participant mindset
    - Encourage participants to show up well-rested and ready to focus on the day.
- **Open question:** participant homework
    - This seems risky. On the one hand, participants might like the idea of preparing for the workshop [Graffinity]. But they may also ignore the homework [E.ON].
    - See also: recruit participants and

Adapt the venue to 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.

- **Consideration:** arrive early to arrange furniture so that it is conducive to a creative atmosphere and supports interpersonal leveling.
    - Example: [DiscoveryJam] could not do this effectively. We think that it hurt the workshop.
- **Consideration:** characteristics of venues that foster creativity: well-lit, neutral, ample space
    - See creativity literature for support [Isaksen2000?]

    - Not always possible due to constraints [CP, Lineage, UPDB], but should still be strived for as in [E.ON].

Prepare to facilitate effectively. This is a general principle on how to facilitate workshops effectively. See also: pilot workshops.

- **Recommendation**: use facilitation resources to prepare for the workshop
    - There are many resources for facilitating workshops.
    - See also: [Hamilton2016], [CPS2015], [Brooks-Harris1999]
- **Recommendation:** lead by example
    - Methods may seem silly, but they have a seemingly significant impact on the day. Starting with a thoughtful answer to the questions helps participants get more comfortable. Repeated feedback from [Graffinty, CP, E.ON]
    - See also: bemoan distractions.

Balance focus with flexibility. Collaborators, especially academics, 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:** lead the workshop
    - Facilitators must be able to keep conversations moving.
    - 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 *"Ethan 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: "***let ideas, not agenda, drive the day"* [Maiden2004].
    - Keep moving through the methods, but realize that discussions of interesting topics should be permitted. This must be learned through experience.
- **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]

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.
- **Recommendation:** restrict observers

    - Observers are another distraction. Especially in visualization projects, there is usually a PI who will attend the workshop but not participate. These observers tend to come and go as they please, distracting participants and facilitators.
    - [Hamilton2016] recommends no observers during the workshop.

Analyzing and acting on workshop results

Gather useful 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 appropriate feedback media.
    - We had limited success using "fun" feedback media, such as postcards [E.ON].
    - We had more success with surveys sent immediately after the workshop [Graffinity, Arbor, CP(?)]
- **Consideration:** request feedback persistently
    - Sending follow up emails increases response rates as in [Arbor].
- **Consideration:** gather feedback from facilitators and scribes in the workshop evaluation

Prepare to be deluged 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. Be prepared for it.

- **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 useful in that it demonstrates a failed method.
- **Recommendation:** dedicate time to analyze output
    - Immediately after the workshop, organize it and set a strategy for how you will make sense of it. See: [analyze data and artifacts]

Analyze data and artifacts carefully. A variety methods can be used to analyze the multi-form workshop output. Analyzing workshop output results in *insights.*

- **Recommendation:** workshops create *qualitative* data
    - Resist the urge to quantify it. The frequency of ideas says little about their importance. For example, important ideas may emerge from discussions and not be recorded on any artifacts.
- **Consideration:** involve collaborators in analysis of output.
    - This can be useful for making sense of jargon or messy handwriting.
    - Ideal collaborators for this are *translators* [Sedlmair2012]. [CP, Graffinity]
- **Consideration:** consider many ways to prioritize and aggregate output from the workshop.
    - Aggregation into themes, categories or tasks. ex) open coding, thematic analysis. Prioritization based on some metrics -- impact, feasibility, novelty, funding. [CP, E.ON]

- **Consideration:** the design activity framework provides a useful vocabulary to describe output as opportunities, constraints and considerations
    - Identifying opportunities, constraints and considerations is useful for planning action with the output [Graffinity]

Workshop insights have broad influence on the design process. 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.

- **Consideration:** workshop insights complement 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.
- **Consideration:** workshop insights are useful for generative 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].
    - Examples include the parallel prototyping that followed workshops in the HTVA and EDINA projects.
- **Consideration:** workshop insights are useful for evaluative methods.
    - Workshop insights provide criteria that can be used with evaluative design methods, methods that winnow the space of ideas for possible designs [McKenna2014].
    - Examples include the *"everything in three clicks"* from E.ON project. And the *"access to underlying database keys"* from Graffinity.
- **Consideration:** workshop insights are useful for documentation and reflection.
    - [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.
- **Consideration*:*** workshop insights are useful for additional workshops.
    - The E.ON project used the output of a requirements workshop as input to a design workshop focused on creating prototype visualizations.
- **Recommendation:** using workshop insights should celebrate the flexibility of workshops.

It is not clear where to put these ideas

- **Recommendation:** Workshops will not save a 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]
- **Recommendation:** Have fun.
- **Consideration:** audio or video record the workshop
    - [Lineage] workshop had good experience doing this. The transcripts from audio helped analysis. However, the audio only captured the conversation of one pair of participants.

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

Compare workshops to other methods

There are many definitions of creativity workshops. They all involve some criteria: group participation, creativity, focus on a goal.

Creativity workshops differ from meetings, interviews, and workshops.

- Interviews: not necessarily participatory.
- Meetings: may not use creativity methods. Not necessarily focused on a goal.
- Workshops: may not creativity methods. Focused on a goal.
- Creativity workshops: use creativity methods. Focused on a goal.