A Framework for Creativity Workshops in Applied Visualization Research

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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. They have been used successfully in a variety of recent projects, there are no established practices for what exactly are creativity workshops or how to use them effectively in visualization. We have analyzed our use of 15 creativity workshops in 8 applied visualization research projects to identify common themes and articulate our experiential knowledge. Through a methodology of critically reflective practice, we developed a framework for describing the practical and theoretical aspects of using creativity workshops in visualization projects. The framework: 1) characterizes creativity workshops by their role in visualization process and decision models; 2) identifies six visualization creativity method attributes for analyzing creativity methods in the context of visualization; 3) proposes a practical and theoretical process model supported by recommendations based in our experience and previous literature; and 4) presents two example workshops for future projects. We intend for this framework to be a thinking tool that provides guidance for running, analyzing, and reflecting on future workshops.
<E: We will keep our names on the submission — TVCG guidelines say submissions are not anonymized.>

Index Terms—User-centered visualization design, design studies, creativity.

1 Introduction

Visualization researchers face distinct challenges in every collaboration with domain specialists. Yet there are also common challenges in collaborations as we search for interesting visualization opportunities within the domain, foster rapport with collaborators, and navigate organizational constraints [52]. This paper is about using *creativity workshops*, structured participatory methods that deliberately and explicitly foster creative thinking, in the early stages of applied research projects. Creativity workshops can have profound impacts on collaborations, as a workshop participant reported to us *"the interpersonal leveling and intense revisiting of concepts made more team progress in a day than we make in a year of lab meetings ... [the workshop] created consensus by exposing shared user needs"* [24].

Creativity workshops bring together a small group of researchers and collaborators for about one day of focused work away from the usual constraints and distractions of day-to-day routines. They provide time to explore interesting problems, to establish open communication, to build trust, and to encourage deep thinking. One a collaborator in a different project described creativity workshops as *"a good way to stop thinking about technical issues and try to see the big picture"* [13].

There is little existing guidance for the visualization community about what exactly are creativity workshops, why they are useful, how to effectively use them, or how to evaluate and report them. While they have been used successfully in a variety of projects, each project is reported with different levels of detail. Goodwin et al. [12] provide a rich description of their experience using workshops, while Kerzner et al. [24] summarize their workshop in one sentence. To understand the potential of creativity workshops, and to use them effectively, visualization researchers must integrate disparate reports from a variety of sources in visualization and other domains.

The other domains that use creativity workshops include the fields of creative problem solving (e.g., [5, 7, 15]) and software engineering (e.g., [20, 21, 22]). We searched work from these domains to better understand creativity workshops in visualization, but these domains do not account for the nuances of visualization design, including: the critical role of data early in the design process [39, 43], the use of specialized process models [36, 53, 60], the sharing of knowledge between visualization researchers and collaborators [64], the fuzzy nature of visualization software requirements [53], the evolution of data and tasks that occur throughout a project [35], and the importance of evaluating and validating design decisions [27].

In this paper, we present a framework that provides guidance on how to design, execute, and analyze effective creativity workshops in applied visualization. It results from a research methodology of *critically reflective practice*, supported by analysis of our collective experience using 15 creativity workshops in 8 applied visualization research projects [11, 13, 12, 23, 24, 28, 41, 63] and two workshops in different contexts [46, 47]. It is grounded in creativity workshop literature from the domains of design [1, 8, 9, 26, 48], software engineering [17, 20, 21, 22, 31, 32, 34] and creative problem solving [7, 14, 15, 38, 42]. The framework is based on the idea that effective workshops establish creative atmospheres, promote creative thinking about domain goals in the context of visualization, generate useful artifacts and knowledge, and encourage continued creativity throughout the collaboration.

This work's **primary contribution** is a framework that supports the use of creativity workshops in visualization research, including:

- background on visualization creativity workshops, describing their role in existing visualization process models and identifying recurring characters (Sec. 2);
- six *visualization creativity method attributes* for analyzing creativity methods in the context of visualization (Sec. 5);
- a *process model* describing how to initialize, design, execute, analyze, and reflect on visualization creativity workshops supported by practical and theoretical *recommendations* based on our experience (Sec. 6); and
- two *example workshops* illustrating the use of our framework that also serve as a starting point for researchers to design their own workshops (Sec. 7).

We intend for this framework to be a thinking tool for researchers considering creativity workshops in their own projects and to communicate our experiential knowledge developed from running workshops in

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a variety of domains.

2 Background and Terminology

This section defines applied visualization research, creativity workshops, and creativity methods. It identifies three types of workshops based on their role in existing process and decision models. And it introduces a vocabulary for describing recurring roles of workhop characters.

2.1 Applied Visualization Research

This paper is about applied visualization projects where visualization researchers (**"researchers"**) work closely with domain specialists (**"collaborators"**) to design visualizations useful for that domain. While there may be cases where an individual is both a visualization designer and a domain specialist, that is outside the scope of our work as we focus on the challenges associated with bridging the gap between researchers and collaborators.

Applied visualization projects usually, but not necessarily, result in published contributions to the field of visualization or the specific domain. Design studies are subset of applied research projects where creativity workshops are valuable [53]. They proved useful in technique-driven work as well [24].

2.2 Creativity Workshops and Methods

Creativity workshops are structured workshops that deliberately and explicitly encourage creative thinking to achieve a goal [5]. Four principles characterize the creative thinking encouraged by workshops: 1) generating new and useful ideas [58]; 2) promoting focused work, open communication, iteration and incubation [50]; 3) exploring a broad space of ideas then winnowing down to the more promising ones [42].

Workshops are composed of **creativity methods**, repeatable processes performed by designers that deliberately and explicitly stimulate creative thinking [1, 6, 36]. We avoid classifying specific methods or workshops as creative or not — all design methods and workshops foster creativity to some extent. Yet creativity methods can be analyzed from different perspectives, including practical and theoretical as we describe in more detail in Sec. 5. In addition to being composed of creativity methods, *creativity workshops are creativity methods*. We analyze the repeatable actions of designers using creativity workshops — such as planning workshops and analyzing their results — using the same set of characteristics.

2.3 Creativity Workshops in Process Models

Design activities characterize the actions of researchers by their goals—to *understand* domain problems, to *ideate* on potential solutions, to *make* prototypes, and to *deploy* applications for evaluation [36]. Visualization creativity workshops can be focused on different design activities: *requirements*, *design*, or *evaluation* [12]. **Creative requirements workshops** to understanding domain problems and eliciting requirements, corresponding to the *understand* and *ideate* activities. **Creative design workshops** explore designs and make the more promising ones, mapping to the *ideate* and *make* activities. **Creative evaluation workshops** elicit feedback to evaluate designs as in the *make* and *deploy* activities.

The workshop focus provides a vocabulary that enables comparison of workshops with similar intent. But this is a simplification of the serendipitous and emergent activity within creativity workshops as they intentionally generate unpredictable, but still useful, ideas. In fact, the knowledge generated from workshops generally influences every aspect of design decisions. More specifically, in our experience workshop ideas impact decisions at every level of the nested model for visualization design [39], from problem characterization to downstream validation.Nevertheless, describing the workshop focus as requirements, design, or evaluation describes the intended outcomes of a workshop. This is useful for analyzing workshops with similar intent.

We focus on creativity requirements workshops for characterizing domain problems and understanding analysis tasks. We focus on this area for three reasons. First, this is a time-consuming and important part of collaboration where researchers often rely on their experiential knowledge to navigate [52]. Second, this is where we perceive the greatest difference between existing workshop literature and visualization practice as visualization workshops must encourage communication between visualization researchers and domain specialists. Third, this is the area where we have the most experience using creativity workshops.

2.4 Creativity Workshop Characters

A consistent vocabulary is needed to describe the individuals involved in workshops. The recurring character roles of workshops include: a *primary researcher*, *project stakeholders*, *a workshop team*, a *primary facilitator*, *co-facilitators*, and *participants*.

The **primary researcher** decides to use a workshop and integrates the workshop outcomes into a research project. They are likely the first-author on the resulting visualization publication. The primary research works with **project stakeholders**, individuals who have interest in the project including collaborators, researchers, and other individuals involved in the project.

The **workshop team** designs, executes, and analyzes the workshop. It consists of a **primary facilitator**, responsible for the entirety of the workshop, and **co-facilitators**, responsible for assisting the primary facilitator. The workshop team is typically 2 - 4 visualization researcher or workshop experts. Domain collaborators may also make valuable contributions to the workshop.

The **participants** actually carry out the workshop methods with guidance from the workshop team. They are often domain collaborators, visualizations researchers, and other project stakeholders. These roles evolved from reflection on our experience, described in Sec. 4.

3 Related Work

<E: This section is a bit flabbier than the others. I'm still not sure what we want to put here.> This section discusses related work to creativity workshops spanning the domains of creative problem solving, software engineering, and visualization.

Creativity workshops originated from creative problem solving [40]. Principles of these methods include encouraging convergent and divergent thinking [42], fostering a creative atmosphere by suspending judgment [7], gaining new perspectives on a problem through metacognition [61], using analytic and intuitive mindsets [38], and using metaphors to foster creativity [14]. 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 [64].

Generating software requirements requires creativity [45] and researchers have tailored existing creativity methods and methodologies, such as Creative Problem Solving, to their field [31]. This includes creativity workshops to engage project stakeholders and to elicit requirements for complex systems [20, 32, 34, 33]. Common parameters of these workshops include a length of 0.5 to 2 days, 18 - 24 participants, and hundreds of ideas generated per workshop [22]. These ideas generated were integrated into requirements engineering processes [21] or more modern agile processes [16]. Although these workshops also provide useful guidelines for visualization workshops, they mention data only implicitly, in contrast to the important role of data early in the visualization design process [29]. There is also no clear relationship between the use of workshops and existing visualization design processes.

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. [25] 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. Slingsby

Year(s)	Workshops	Our analysis
2004 - '09	Creativity workshops applied to software req. engineering (SJ)	
2009	EDINA workshop (JD)	
2010 - '13	E.ON workshop (SJ + SG + JD) HTVA workshop (JD)	Applied software req. workshops to visualization (SJ + SG + JD)
2015	Graffinity workshop in design study (EK + MM) CP workshop in design study (SG)	Reconciled differences of workshops (EK + SG) Speculated on guidelines for future workshops (EK + SG) Reviewed literature with narrow scope: creativity methods (EK)
2016	Discovery.Jam (EK*)	Reviewed literature broadly: creativity, creativity support (EK) Analyzed E.ON and Graffinity workshops in detail (EK + SG)
Spring 2017	UPDB workshop (EK + MM) Lineage workshop (EK*) Arbor workshop (EK + MM)	Revisited experiences, interviews on EDINA and HTVA projects (EK, JD) Interviewed software req. engs about creativity workshop (EK + SJ) Reviewed literature on workshops for business, problem solving (EK)
Fall 2017	DiscoverJam 2017 (EK*)	Identified 85 mini-insights from previous discussions and analysis (EK + MM) Writting: create insights supported by recommendations, and considerations (EK + MM) Reviewing and supporting insights with experience (SG + JD) Writing draft (EK + SG)
		*other researchers (not co-authors) significantly contributed to these workshops

Fig. 1. Timeline of our intertwined action and analysis. <E: This timeline will show who was involved with what actions we performed. The data for this timeline is in this doc: https://tinyurl.com/y969j34l>

et al. [56] 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. This paper is the first rigorous analysis of creativity workshops in visualization, based on our extensive workshop experience which we describe next.

4 Experience and Research Process

This section describes our collective experience of projects that used one or more workshops and workshops used in contexts similar to applied visualization. It also describes the research methods that we have used to articulate our experiential knowledge and contextualize it with existing practice and theory.

4.1 Workshop Experience

Our understanding of workshops evolved through 10 years of using creativity workshops in a variety of domains. Tab. 1 summarizes our 8 research projects and Tab. 2 summarizes workshops in each projects. We refer to projects by unique IDs (e.g., [P1 – P8]) and workshops by unique IDs within a project (e.g., [P1.R]).

We initially described workshops as *imagination exercises* in a design study with geographic information system (GIS) developers [P1]. Although they were not called creativity workshops, we deliberately fostered creativity in structured workshops for requirements [P1.R], design [P1.D], and evaluation [P1.E].

A similar pattern was used in the project that introduced the term *creativity workshop* to visualization. In a design study with energy analysts [P2], we worked closely with software requirements engineers to deliberately and explicitly foster creativity in requirements gathering [P2.R], design with researchers [P2.D1], design with collaborators [P2.D2], and evaluation [P2.E].

This inspired the use of creativity requirements workshops in a variety of projects, including design studies with constraint programmers [P4], neuroscientists [P5], psychiatrists [P6], genealogists [P7], and biologists [P8]. In these projects, the workshop output was used in traditional user-centered design processes, such as parallel prototyping, instead of being input to additional workshops.

As every domain collaboration has specific challenges, the diversity of projects in terms of their context, collaboration, and results increases the potential usefulness of our reflection. Overall, we have used creativity workshops in different types of organizations: industry companies [P1, P2], a defense agency [P3], and academic labs [P4 – P8]. We had a variety of outcomes, including visualization publications [P1 – P6], a grant application [P8], and one failure [P7].

We also draw on experience using workshops outside the context of applied visualization research. We designed and facilitated two conference-based workshops at IEEE Vis [46, 47]. Aimed at exploring visualization approaches to domain-specific data, these workshops are not included in our experience above as they were not part of a larger collaboration. Also, one co-author has extensive research applying creativity workshops to software requirements engineering [8, 9, 17, 20, 21, 22, 32, 33, 34]. Although these experiences were not part of visualization research projects, they provide important details about aspects of involving data in workshops.

4.2 Research Process

This works results from **reflection** — the analysis of experiences to generate insights [2]. More specifically, we applied **critically reflective practice**, a methodology of *"synthesizing experience, reflection, self-awareness and critical thinking to modify of change approaches to practice"* [59]. This research was performed through a two year collaboration that intertwined analysis and action (shown in Fig. 1). Our understanding of workshops evolved through this process.

<E: MM and I will finish this section after we've finished the research...Methods that we used have include: discussing, writing, thinking, experience and reflection-in-action [51], literature review, reflection-on-action, writing, discussing, reflection-for-action [59], observations-to-insights [26], insight sorting [26], writing...>

5 Visualization Creativity Methods

Through reflecting on our experience and reviewing existing literature, we developed six theoretical and practical attributes for analyzing visualization creativity methods. It is important to note the duality of creativity methods in this context: workshops are creativity methods and workshops are composed of creativity methods. In fact, we use attributes described in this section throughout the process model for creativity workshops (Sec. 6) and in the example workshops (Sec. 7).

These attributes are based previous work for analyzing creativity methods. We adopt and extend the framework for creativity methods proposed by Biskjaer et al. [1]. More specifically, we add vocabulary for methods in workshops with a clear distinction between participants and facilitators, methods that involve visualization, and methods that create artifacts and support collaboration in the context of applied visualization.

5.1 Concrete Aspects

The **concrete aspects** of methods are the physical, tangible, and observable attributes [1]. They include a **process**, describing the intended actions performed during a method by the facilitators and participants. The process is usually categorized by the amount of direction given to participants [4], from unstructured (e.g., brainstorming [42]) to structured (e.g., storyboarding [26]).

The process describes how the method employs physical components. **Prompts** present information relevant to the method, including handouts or slides. **Materials** are consumed as part of a method—e.g., post-it notes used to record ideas. **Tools** are used to transform materials into artifacts—e.g., a pen used to write on a post-it note. **Artifacts** are the tangible output of methods. Artifacts can also be input to methods—such as when post-it notes created during brainstorming are later organized.

5.2 Creative Atmosphere

The **atmosphere** refers to emotional environment that encourages creative thinking. It includes fostering unencumbered sharing of ideas [49]; promoting inter-personal leveling [19]; and encouraging confidence and willingness to take risks [40]. We have found that two characteristics of methods can influence the extent to which workshops foster a creative atmosphere: trust and agency.

Trust between participants and facilitators leads to open communication, the uninhibited sharing of ideas between individuals<E: Need citation> . This can be achieved by demonstrating an intent to listen, and demonstrating vulnerability [3].

Agency is the feeling of ownership, responsibility, and ability to act [3]. Agency can be promoted by using methods that encourage multi-directional communication between workshop participants and facilitators [3]. Methods that encourage the one-way communication, such as lectures, are notorious for hindering agency [29]. Yet, this is a mistake we made repeatedly [P8.R].

ID	Domain	Collab.	Purpose	Workshops	Result	Ref.
P1	Cartography	Industry	*"Reimagining the legend as an exploratory visualization interface"*	3	InfoVis paper	[11]
P2	Smarthome	Industry	Deliver insights into the role of Smarthomes and new business potential	4	InfoVis paper	[12]
P3	Human terrain	Defense	*"develop [visualization] techniques that are meaningful in HTA"*	3	InfoVis paper	[63]
P4	Constraint prog.	Academic	Design performance profiling methods for constraint programmers	1	VAST paper	[13]
P5	Neuroscience	Academic	Create novel visualization techniques for multivariate graphs	1	EuroVis paper	[24]
P6	Psychiatry	Academic	Create visualization tools to analyze determining or associated factors of suicide	1	TVCG paper	[41]
P7	Genealogy	Academic	Create visualizations to support genealogy analysis	1	None	[23]
P8	Biology	Academic	Create visualization software for phylogenetic analysis	1	Grant app.	[28]

Table 1. We have used creativity workshops in 8 applied research projects—6 of projects resulted in publications [P1, P2, P3, P4, P5, P6], 1 resulted in a grant application [P8] and 1 was abandoned as a failure [P7]. We refer to projects by their ID because this work contains details about the workshops that did not appear in their corresponding publications. These projects have been intertwined with our analysis (as shown in Fig. 1). For more details on the individual workshops, please refer to Tab. 2. <E: We compiled our unabridged experience in this doc: https://tinyurl.com/y84cfut5. Please submit corrections as edits to that.>

ID	Focus	Goal	Length (hrs)	Team	Partic. (collab)	Partic. (vis)
P1.R	Req.	Explore possibilities for enhancing legends with visualizations	6	1	7	3
P1.D	Des.	Candidate solutions identified and considered in light of identified requirements	6	1	—	3
P1.E	Eval.	Presentation and evaluation of deliverables	4	1	3?	3
P2.R	Req.	Identify future opportunities for utilising smarthome data/technologies	6	3	5	0
P2.D1	Des.	Develop concepts from req. workshop in an agile approach	4	2	0	6
P2.D2	Des.	Elicit feedback from prototypes and prioritize design improvements	3	2	7	0
P2.E	Eval.	Evaluate final prototypes	3	2	5	0
P3.R	Req.	Identify novel visual approaches most suitable for HTA	9	2	6	7
P3.D	Des.	To further establish requirements ... to acquire feedback on initial designs	7	1	3	6
P3.E	Eval.	Structured evaluation against scenarios	4	1	3	6
P4.R	Req.	Identify analysis and visualization opportunities for improved profiling of cons. prog.	2	7	10	0
P5.R	Req.	Find opportunities for visualization in retinal connectomics and identify shared user needs	7	4	9	0
P6.R	Req.	Understand the main tasks of psychiatric researchers	3	2	6	1
P7.R	Req.	Find opportunities for a design study with genealogists	3	1	7	3
P8.R	Req.	Find opportunities for funded collaboration between vis. and bio.	7 x 2	2	10	2

Table 2. Our workshop experience includes 15 workshops in a variety of projects. Common characteristics of workshops include number of participants ranging from 3 to 10 and duration ranging from 3 to 9 hours. While our analysis draws on all workshop experience, this paper focuses on workshops for requirements. <E: We still need to figure out what data to show here.>

5.3 Creative Thinking

Creative thinking is how methods encourage participants to explore an *idea space*, often through explicit *creativity triggers* to encourage a certain type of thought.

The **idea space** categorizes methods by their impact on the emergent ideas. Methods can encourage **divergence**, expanding the idea space by generating ideas, or **convergence**, winnowing the idea space by evaluating or synthesizing ideas [42]. Methods can also support **incubation**, by encouraging thinking without the explicit goal of diverging or converging. Creativity literature advocated for methods for incubation, such as through unstructured breaks [50].

Creativity triggers describe how methods intend to foster different types of creativity. **Analogy** is the transfer of concepts between domains, while **metaphor** is the transfer of concepts between a specific domain and abstract concept [1]. **Randomness** is the extent to which unpredictable stimuli are included, such as rolling a die or shuffling a deck of cards. **Scale** is the level at which participants are generating and sharing ideas, such as individually, in small groups, or in large groups. There is an implicit connection between scale and randomness as groups can be shuffled throughout the workshop. **Iteration** refers to whether methods explicitly or implicitly revisit ideas from early methods, such as by sorting post-it notes.

5.4 Visualization

We propose four constructs to describe how creativity methods can explore the relevant domain analysis goals and data in the context of visualization: the *data-focus*, *analysis context*, *visualization features* and *automation context*.

The **data-focus** is how a method incorporates domain data and whether it is investigating the real data or the perception of data. Real data is explored by providing visualizations of data or machines with datasets pre-loaded. Data perceptions are explored by asking participants about their data in the abstract.

The **analysis context** describes the connection between a method and the existing workflows or conventions. Analysis context ranges from concrete to abstract. A concrete analysis context examines the existing workflows, conventions and tools. For example, when working with neuroscientists, we used screenshots of their tools to elicit ideas [P5.R]. An abstract analysis context is more about unconstrained possibilities, such as our workshop with energy analysts looking for wide-ranging future applications of smarthomes [P2.R].

The **visualization features** describe the data visualizations included in a method. These include the use of **visual components**, such as the example visualizations shown in *Visualization Awareness*. Methods may also incorporate **visual language** around how data is represented. This can be used explicitly or implicitly. An example explicit use of visualization language is asking *"what would you like to see?"*. Implicit visual language are methods that ask participants about visual representations, such as the positive and negative characteristics of existing visualizations [P1.R].

The **automation aspects** explore the role of automation, an important part of applied visualization research that aims to balance between information location and task clarity [53]. We have examined automation context with implicit language, for example, asking participants to assume part of their workflow had been automated [P5.R]. Explicit exploration of automation could be an interesting area for future work (see Sec. 8).

5.5 Useful Artifacts and Knowledge

Generating useful artifacts and knowledge is about how ideas are preserved. It relates to **externalization** of ideas—how they are represented in a physical medium. In general, anything that does not get recorded in a physical artifact will be lost. Post-it notes are a common material used in workshops because they are a physical media that easily supports more analysis, such as *prioritization* and *aggregation*.

Prioritization describes ranking ideas by some metric, such as importance or feasibility. Two of our workshops asked participants to rank ideas by importance, providing guidance to designers later in the collaboration [P1.R, P3.R]. In contrast, other workshops deliberately avoided ranking as it relied too much on subjective interpretation of difficulty and feasibility — while these workshops were successful, interpreting the results required tremendous effort (see also: Sec. 6).

Aggregation describes whether methods define meaningful sets of artifacts. One workshop used explicit clustering of ideas to reduce hundreds of post-it notes to tens of idea clusters which could be explored in more detail [P8.R].

5.6 Continued Collaboration

Workshops are one small slice of a complex interactions between us and our collaborators. Methods can foster continued creativity in the collaboration by providing **closure**, or a sense of resolution at their conclusion. Closure can be provided by clearly articulating what will happen with the workshop results [15].

6 Visualization Creativity Workshop Process

Although every project is different, workshops follow similar processes. They start with *initialization*, deciding to use a workshop and identifying workshop constraints. Related to initialization is *design*, selecting methods for the workshop. Following design is *execution*, running the workshop. After execution is *analysis*, generating knowledge from the workshop outputs. Forward linear movement through these four stages forms a process model for running workshops. Permeating this process model is *reflection*, carefully documenting and analyzing the decisions throughout the process.

This process model is supported by our experience and workshop literature [3, 15, 58]. In this section, we describe the results of our collective reflection, articulating experiential knowledge as recommendations for each stage of the model. The recommendations are summarized in Tab.8.

6.1 Initialization

Initialization involves deciding to run a workshop, identifying workshop constraints, and recruiting the workshop team and participants. The first step of initializing a workshop is deciding who will be responsible for coordinating the workshop and using the output. **Identifying the primary researcher** [J.1] should be performed early on. The primary researcher is likely the first author on resulting visualization publications. Without a primary researcher, workshop results will likely go unused. In our failed project, the primary researcher was not clearly defined [P8.R].

Understanding and **articulating the workshop purpose** [J.2] will help with the workshop design and provide evaluation criteria. This requires assessing project's current state in visualization process models. Requirements workshops (the focus of this paper) fulfill the *understand* and *ideate* design activities [36]. We have used them to characterize broad domain challenges (e.g., [P8.R]) and to identify specific analysis needs (e.g., [P6.R]).

If considering a workshop at the start of a collaboration, **evaluating design study preconditions** [J.3] will help assess the project's viability. An important precondition is the time commitment from collaborators. In our failed project [P8], our collaborators were too busy to meet with us before the workshop. In retrospect, this should have been a warning for continued collaboration. Another important precondition is the availability of data though workshops can help with this. Working with collaborators with sensitive data, we used a workshop to identify surrogate data with similar characteristics, replacing sensitive defense data with online business reviews [P3].

Recognizing workshop constraints [J.4] — such as the availability of collaborators and budget — helps in designing effective workshops. The availability of collaborators influences the number of workshops and their duration. One project was constrained explicitly to three meetings with collaborators, which we used to create three workshops [P1]. With respect to duration, one day (6 - 8 hours) seems to be sufficient. Our half day workshop [P6.R] felt rushed and did not allow incubation and iteration on ideas, though the results were still valuable. One workshop spanned two days [P8.R] as it required participants to travel from out-of-state, though two working days is a large commitment for collaborators who are not traveling.

Constraints also include the venue. Creativity literature expounds the importance of neutral, well-lit venues [5, 18]. We have had success with such venues [P2.R, P3.R] but have also had success hosting workshops in on-site conference rooms chosen in order to meet the project constraints [P4.R, P5.R, P6.R]. The venue affordances, such as the room size and physical layout, are important factors in selecting locations.

Recruiting a workshop team [J.5] is important as they team design, execute, and analyze the workshop. The team is usually visualization researchers with some understanding of domain language and terminology. In domains where vocabulary is complex, or time is limited, domain collaborators may make valuable team members as they assist in bridging the language gap between researchers and collaborators [P4, P8]. We have also relied on professional facilitators to assist in executing the workshop [P2.R, P3.R], though all other workshops were facilitated by visualization researchers.

Selecting **diverse and creative participants** [J.6] can contribute to workshop success [5, 14]. We have (sometimes unintentionally) recruited participants that are diverse in many ways, including: their seniority (e.g., graduate students to senior researchers [P5.R]), technological fluency [P8.R], specialization in the domain (e.g., practitioners, tool-builders, teachers, and students [P4.R]), and place of work (e.g., industry and academia [P4.R, P8.R]). We have also recruited participants for their creativity or openness to new ideas based on survey responses [P4.R]. These surveys had the additional benefit of eliciting ideas that could be explored in more detail in the workshop.

Labeling stakeholders as workshop team members or participants may encourage an *us-versus-them* mentality, and should be avoided by **blurring the boundary between researchers and collaborators** [J.8]. Blurring the boundaries encourages open communication while fostering trust and agency. This can be planned, for example, by including researchers as participants [P1.R, P3.R]. It can also be improvised, such as when the venue's interconnection failed and we relied on a workshop participant to provide WiFi on their phone [P2.R], providing a sense of ownership over the workshop results.

Avoiding poppers [J.7] will help to reduce distractions in designing and executing workshops. Hamilton [15] defines *poppers* someone who *"pops out of the workshop for a meeting"* or *"pops into the workshop for an hour."* Poppers distract facilitators and participants from the workshop and should be avoided. Clearly communicating the expectations to participants and workshop members, both in person and in writing, can be useful for determining dedication of potential contributors.

6.2 Design

After deciding to run a workshop, it must be designed for the current collaboration. The result of design is a flexible workshop plan that describes the methods we *might* use, the effect they *might* have on the workshop, and the output that they *might* produce. We emphasize flexibility in the plan as the reactions of workshop participants are unpredictable — in many cases we have deviated from the plan with successful results. Creating the plan is an iterative process of proposing methods, testing methods, and improving based on the results of the tests. We recommend designing workshops with the end in mind, and selecting workshop methods effective for visualization research.

The purpose of running a workshop is to collect artifacts that express the needs, concerns, and thoughts of domain collaborators with respect to visualization software requirements. The workshop should be **designed for analysis** of its artifacts [D.1], for example, by selecting methods that promote externalization. Using methods that result in artifacts, such as post-it notes, will make it easier to analyze workshop results. All of our requirements workshops had participants writing ideas on post-it notes. We have found that mapping post-it note colors to specific methods (or specific prompts within methods) makes it easier to connect ideas throughout the workshop.

Careful attention should be paid to **select an appropriate data focus and analysis context of the workshop** [$\mathcal{D}$.2] from the perspective of researchers and collaborators. Scoping the workshop to appropriate contexts requires traditional user-centered design methods before the workshop. Interviews provide an understanding of collaborator's needs. In one project, we spent about ten hours interviewing neuroscientists before deciding on a creativity workshop [P5]. Surveys also provide valuable information for scoping the workshop [P4]. Tailoring a workshop to the specific analysis needs helps to build trust between researchers and collaborators. It is also related to identifying project constraints [$\mathcal{J}$.4] and intellectual considerations of design design studies [53].

To select workshop methods, we start at a high level of abstraction: **workshop methods follow a pattern: diverge then converge** [$\mathcal{D}$.3]. They explore a broad idea space before evaluating ideas and exploring the more promising ones [5, 42]. The diverge-converge pattern implies workshops should start with active, generative, and divergent methods followed by active, evaluative, convergent methods. A mix of passive methods supporting incubation (such as breaks) and iteration (such as discussing ideas in a large group) should be mixed into this structure. Converging can be done implicitly, such as asking participants to draw storyboards that connect all the ideas of the day [P2.R, P4.R, P5.R]. It can also be explicit, such as asking participants to cluster ideas and describe the clusters [P8.R]. Implicit convergence is shown in one of our example workshops in Sec. 7.

As participants will have different ways of thinking and working, **select methods that support many styles and many paths** [$\mathcal{D}$.4] to elicit ideas from everyone [55]. The creativity method attributes provide important constructs for creating a workshop with balance and variety of methods. All our workshops involve a mix of individual ideation (individual scale), small group ideation (small scale), and large group discussion (large scale). We balance active methods, such as brainstorming, with passive methods, such as breaks. Careful attention should be paid to methods that require drawing. In one workshop participants struggled with the storyboarding method because they were not comfortable drawing in that style [P5.R].

Starting workshops should foster a creative atmosphere, by **establishing agency and trust** [$\mathcal{D}$.5]. Introduction methods are a valuable tool for encouraging creative thinking. Effective introductions support interpersonal leveling by encouraging the display of vulnerability. Even in the case where groups of particpants work together regularly, the introduction method provides an opportunity for participants to get to know the workshop team. One particularly effective method includes *introduce yourself as a plant or animal* as reported from one of our projects, *"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"* which helps to establish trust and agency [P2.R].

The specific methods should **incorporate data and visualization** [$\mathcal{D}$.6], but they can be selected from a variety of resources for design [26, 30, 37, 54, 61], visualization [36], and creativity literature [5, 14, 15]. A visualization-tailored method that we have repeatedly used is *Wishful Thinking* where participants identify aspirations. We tailored it to visualization by including in the prompt: *For [some data and analysis questions] ... What would you like to be able to know? What would you like to be able to do? And What would you like to be able to see?*

Another visualization-specific method is *Visualization Awareness* where facilitators show variety of visualizations while participants are asked think about how the visualizations apply to their domain. This method encourages creativity through analogy. Selecting visualizations for this method required judgment, but we have generally selected a mix of seemingly unrelated visualizations (to promote divergent thinking), visualizations that you created (to show authority and credibility), visualizations that you did not create (to show knowledge of the field), older visualizations (to show depth of knowledge), and playful visualizations (to support many styles and many paths). This method has generated many interesting discussions, such as *"what does it mean for legends to move?"* [P1.R], *"what does it mean for edge to flow?"* [P2.R], and *"what does it mean for neurons to rhyme?"* [P5.R].

Workshop methods should **provide closure** [$\mathcal{D}$.7] to continue creative collaborations. This can include reflective activities, where participants are asked *"what do you know now that you did not know this morning?"* [P2.R, P5.R, P4.R]. It can include prioritization where participants select items that they consider important [P1.R,P3.R]. And it can involve aggregation, where participants identify themes or groups of ideas [P8.R].

While designing a workshop, the methods should be **tested and improved with pilot workshops** [$\mathcal{D}$.8]. Early in the design process, pilot workshops test whether methods are easy to understand, that they elicit appropriate artifacts, and that they are clearly explained. Closer to the workshop, piloting establishes expectations of the workshop team. It is important to pilot with the real materials that the methods will use. This will help ensure that materials have proper affordances — a common mistake made here is that post-it notes are the wrong size for certain methods [P5.R]. It also finds errors in the prompts, limiting distractions during the workshop [P2.R, P5.R, P6.R, P8.R]. Pilot workshops can include proxy participants such as visualizations researchers [P2.R] or domain collaborators [P8.R]. To avoid mistakes, all workshops and methods should be piloted to some extent. But, piloting does not capture the complexity of executing the workshop with real participants.

6.3 Execution

Following design, the workshop is executed. The team facilitates it with participants to collect artifacts and generate knowledge. This section focuses on effective execution from the perspective of visualization: to promote creative thinking about domain goals in the context of visualization, generate useful artifacts and knowledge, and encourage continued creativity throughout the collaboration.

The workshop team should **review existing guidance on how to execute workshops** [$\mathcal{E}$.1]. A full discussion of how to effectively execute workshops is outside the scope of this paper, but guides on general workshops are a useful resource for this [3, 5, 15, 30, 57]. A summary of principles from these guides includes: being energized, providing encouragement, demonstrating acceptance, using humor, being prepared, and ending on time.

More concretely, the team should start with **preparing for execution** [$\mathcal{E}$.2] by gathering appropriate materials and preparing the venue. Furniture should be arranged to make the space feel co-owned, promoting agency, and supporting interpersonal leveling. A semi-circle seating arrangement works well for these goals [62], but there are likely other solutions too. A mistake in one of our workshops was to have the speaker using a podium, which implied a hierarchy between facilitators and participants, hindering communication [46].

The workshop team should **execute with analysis in mind** [$\mathcal{E}$.3] by focusing on creating useful knowledge and artifacts for the collaboration. Workshops produce a tremendous amount of information and discussions are ephemeral: anything not written down will likely be lost. In one case, audio recordings provided valuable information [P6.R], but this workshop was shorter than the others, producing shorter recordings. In general, recording requires a tremendous amount of time to transcribe and analyze after the workshop [29]. Recording may also hinder creativity as participants become self conscious. Overall, we execute with analysis in mind by documenting everything through note taking or methods that create artifacts. The primary facilitator should clearly communicate expectations about note taking and documentation with the co-facilitators — pilot workshops help with that [$\mathcal{D}$.8].

Facilitators should **guide the workshop to foster creativity** [$\mathcal{E}$.4]. This is an active process requiring the facilitators to guide participants through methods, allowing for exploration while moving toward a common goal. Facilitators should intervene in conversations that deviate from the day's focus. This requires careful judgment to determine if a conversation will be fruitful or not. Although it can be intimidating to redirect the conversation, participants will appreciate the focus. When allowed to discuss freely, participants commented

"we had a tendency to get distracted [during discussions]" [P5.R]. Whereas more active facilitation and guidance, resulted in feedback: *"we were guided and kept from going too far off track despite our tendencies to do so. This was very effective."* [P8.R].

Facilitators should actively balance their guidance with flexibility. In some cases, **embracing flexibility** [$\mathcal{E}$.5] by deviating from the plan will be effective. In one workshop, participants proposed a method that would be more useful for their goals by exploring data analysis scenarios [P3.R]. Facilitators should interpret group dynamics to adapt to the changing situation [3].

Facilitators must recognize the difference between being flexible and getting distracted. They should **bemoan distractions** [$\mathcal{E}$.6], including tangential discussions. Another common distraction is communication with outside the workshop through, e.g., e-mail. A ground rule of limiting devices, or when devices are necessary limiting communication, will help ensure participants think deeply during the workshop. Limiting distractions should apply to anyone who is involved in the workshop, both participants and facilitators alike.

Concluding execution, **gather feedback to evaluate and improve workshops** [$\mathcal{E}$.7]. Surveys are one way to gather feedback from participants. We have had successful results collecting online survey responses within 24 hours of completing the workshop. An example survey is included with our results in Sec. 7.

6.4 Analysis

We analyze workshop output to generate actionable knowledge that influences the design process in ways that are both profound and subtle.

Preparing for analysis, the primary researcher should **brace for a deluge of data** [$\mathcal{A}$.1] by explicitly allocating time to analyze the workshop outputs, which typically involve hundreds of post-it notes, sketches, and other notes. This often requires more time than the workshop itself, tens of hours spread over days or weeks allowing for focused work and periods of incubation.

Analysis usually starts by typing or photographing artifacts into documents or spreadsheets. This allows the analyzer to become familiar with all ideas in the artifacts. It also enables sharing the output to **enlist diverse stakeholders** [$\mathcal{A}$.2] — such as collaborators or other workshop team members — in making sense of the results. This is important in domains with complex vocabulary. It is also useful when working with collaborators who have messy handwriting.

The workshop output should be **analyzed with creativity in mind** [$\mathcal{A}$.3] to generate new and useful insights about the domain challenges in the context of visualization. Workshop outputs are diverse and descriptive. We use qualitative analysis methods to make sense of this rich data source. We describe qualitative analysis methods as creativity methods because generating software requirements is inherently a creative process [45].

Analysis methods vary by researcher, but they rely on some form of aggregation and prioritization. Aggregation involves grouping ideas into common themes or goals, such as identifying broad opportunities for visualization in terms of goals and tasks [P2.R, P5.R, P4.R]. When aggregating results, the sets of ideas and the individual ideas should be considered carefully. Prioritization involves ranking ideas based on some metric — usually perceived impact to the domain or development costs. Having participants prioritize ideas during the workshop can provide valuable guidance to visualization researchers [P1.R, P3.R], but may assume that participants have sufficient knowledge of what is possible with visualization. In some projects, we explicitly avoided prioritization because of this limitation [P2.R, P5.R].

Overall, **expect messy outputs from analysis** [$\mathcal{A}$.4] that warrant continued action. Workshops are one piece of an on-going design conversation between researchers and collaborators. Workshop results can be used to guide that conversation. We have used results in varying ways: to identify areas for collaboration and to pursue funding opportunities [P8.R], to focus contextual inquiry on certain parts of a domain problem before building prototypes [P5.R], to build prototypes [P1.R, P2.R, P3.R], and to evaluate and improve existing prototypes [P6.R]. Overall, workshops should be viewed as complementary to other design methods familiar to the visualization community.

		Intent		Idea Generation			Thought Paradigm			Triggers		Scale		
		Develop Trust	Exert Agency	Diverge	Incubation	Converge	Preserve	Bend	Break	Analogy	Iteration	individual	small	large
Method	Sub-method													
Opening		■												
Ice Breaker	Animal	■	■						■					■
Wishful Thinking	Know/Do/See	■	■	■			■	■			■	■	■	■
	What Next...		■					■	■					
Break					■									
Constraint Removal	Identify		■				■							■
	Removal			■				■			■		■	
Lunch					■					■				
Visual Analogies	Analogies	■		■					■	■		■		■
	Likes/Dislikes	■	■			■	■	■						
Break					■									
Storyboarding		■	■			■	■	■			■	■	■	■
Closing		■												

Fig. 2. <E: An incomplete> matrix showing the intent of methods in our example workshop. We categorize methods based on the constructs described in Sec.5

6.5 Reflection

Reflection should be intertwined with the process of initializing, designing, executing, and analyzing workshops. Through reflection, we can track provenance of design decisions and identify practices for future workshops. <E: This section is important, but incomplete.>

Reflect on workshop efficacy early and often [$\mathcal{R}$.1] by comparing expected results with real outcomes. Use this to report on what method work well or not in workshops... <E: How to do this?>

Use workshop results to **discover design decision provenance** [$\mathcal{R}$.3]. This can help in validating designs, such as comparing the final prototypes with ideas identified in requirements workshops [P1.R,P2.R,P5.R]... <E: So what?>

Report the workshop purpose, process, and influence [$\mathcal{R}$.4]. Quantitative analysis methods, such as counting the outputs of specific methods can be used to justify workshops to collaborators, supporting continued collaboration [P4.R]. It can also be used to share practices with the visualization community. Use supplemental material of publications to share workshop materials...

<E: Need transition to next section.>

7 Example Workshops

This section summarizes two example workshops that may be a useful starting point for visualizations designers who want to apply workshops in their own projects.

<E: This is still very much a work in-progress. These figures may be included as supplemental material instead of figures in the text.>

<E: Fig. 2 shows an (incomplete) matrix of intent, characterizing workshop methods using the constructs described in Sec. 5.>

<E: Fig. 3 visualizes the process of our example full day requirements workshop.>

8 Discussion

This section discusses the tradeoffs of research based in reflection, describes the intended use of ideas in this paper, compares creativity requirements workshops to other methods, and outlines areas for future work.

8.1 Critically Reflective Practice

Critically reflective practice is appropriate for analyzing our experiences when compared to other research approaches. It captures experiential knowledge and subjective interpretation of experience that is omitted in grounded theory, thematic analysis and similar qualitative methods. Through rigorous reflective methods, we have reached a consensus on the interpretation of our experiences and agreed on prescriptive recommendations for future workshops.

ID	Headline	Details
$\mathcal{I}.1$	Identify the primary researcher	<E: This column could include a brief justification and references to our workshops or external literature>
$\mathcal{I}.2$	Articulate the workshop purpose	
$\mathcal{I}.3$	Evaluate design study preconditions	
$\mathcal{I}.4$	Recognize project constraints	
$\mathcal{I}.5$	Recruit an effective workshop team	
$\mathcal{I}.6$	Recruit diverse and creative participants.	
$\mathcal{I}.7$	Avoid poppers	
$\mathcal{I}.8$	Blur the boundaries	
$\mathcal{D}.1$	Design for workshop analysis	
$\mathcal{D}.2$	Understand the the data focus and analysis context	
$\mathcal{D}.3$	Follow a pattern: diverge then converge	
$\mathcal{D}.4$	Select methods that support many styles and many paths	
$\mathcal{D}.5$	Establish agency and trust	
$\mathcal{D}.6$	Incorporate data and visualization	
$\mathcal{D}.7$	Provide closure	
$\mathcal{D}.8$	Test and improve designs with pilot workshops	
$\mathcal{E}.1$	Execute with analysis in mind	
$\mathcal{E}.2$	Prepare for execution	
$\mathcal{E}.3$	Execute with analysis in mind	
$\mathcal{E}.4$	Guide the workshop to foster creativity	
$\mathcal{E}.5$	Be flexible in workshop execution	
$\mathcal{E}.6$	Bemoan distractions	
$\mathcal{E}.7$	Gather feedback to evaluate and improve workshops.	
$\mathcal{A}.1$	Brace for a deluge of data.	
$\mathcal{A}.2$	Enlist diverse stakeholders in analysis	
$\mathcal{A}.3$	Analyze with creativity in mind	
$\mathcal{A}.4$	Expect messy output that warrant action	
$\mathcal{A}.5$	Steer the project based on workshop results.	
$\mathcal{R}.1$	Reflect on workshop efficacy early and often.	
$\mathcal{R}.2$	Connect workshop methods to insights.	
$\mathcal{R}.3$	Discover decision provenance in analysis.	
$\mathcal{R}.4$	Report the workshop process, purpose, and influence.	

Table 3. List of recommendations corresponding to each stage of the process model creativity requirements workshops, including initialization [$\mathcal{I}$], design [$\mathcal{D}$], execution [$\mathcal{E}$], analysis [$\mathcal{A}$], and reflection [$\mathcal{R}$]. Recommendations are likely beneficial courses of action supported by our experience and existing workshop literature.

We recognize that prescriptive recommendations do not exhibit predictive validity. This is a common challenge in applied and ecologically valid research, especially where creativity is involved. Creativity relies on intrinsic motivation [40], which can be hard to replicate in controlled environments for laboratory experiments.

8.2 Intended Use of this Framework

We intend for this framework to provide descriptive language about the intent of workshops, workshop methods, and workshop analysis. All recommendations are meant to describe a likely beneficial courses of action based on our experience. They are not predictive. Nor do they exhaustively describe all the characteristics of creativity workshops. In fact, one strength of creativity workshops is that they are a flexible method that can fulfill many roles in the design process. Our framework should be used in a way that supports the divergent use of creativity workshops—celebrating their flexibility and exploring their possibilities.

8.3 Comparison of Workshops to Other Methods

<E: We compare workshops to other methods that explicitly and deliberately encourage creativity in the context of visualization. This includes the five design sheet methodology [44], parallel prototyping [10],...what else?>

<E: Should we compare our framework with existing methodologies for using workshops, e.g., CPS [5]>

8.4 Future work

We focused our collective reflection and analysis on creativity requirements workshops, used for the *understand* and *ideate* design activities. We hope to continue this analysis to describe our experience using workshops for the *ideate* and *make* design activities too.

9 Conclusion

This paper presented a framework that describes the purpose and process of using creativity requirements workshops in applied visualization research. Based on our collective experience using 15 workshops in 8 visualization projects, the framework is about using workshops to establish creative environments, promote creative thinking about domain goals in the context of visualization, generate useful artifacts and knowledge, and encourage continued creativity throughout the collaboration.

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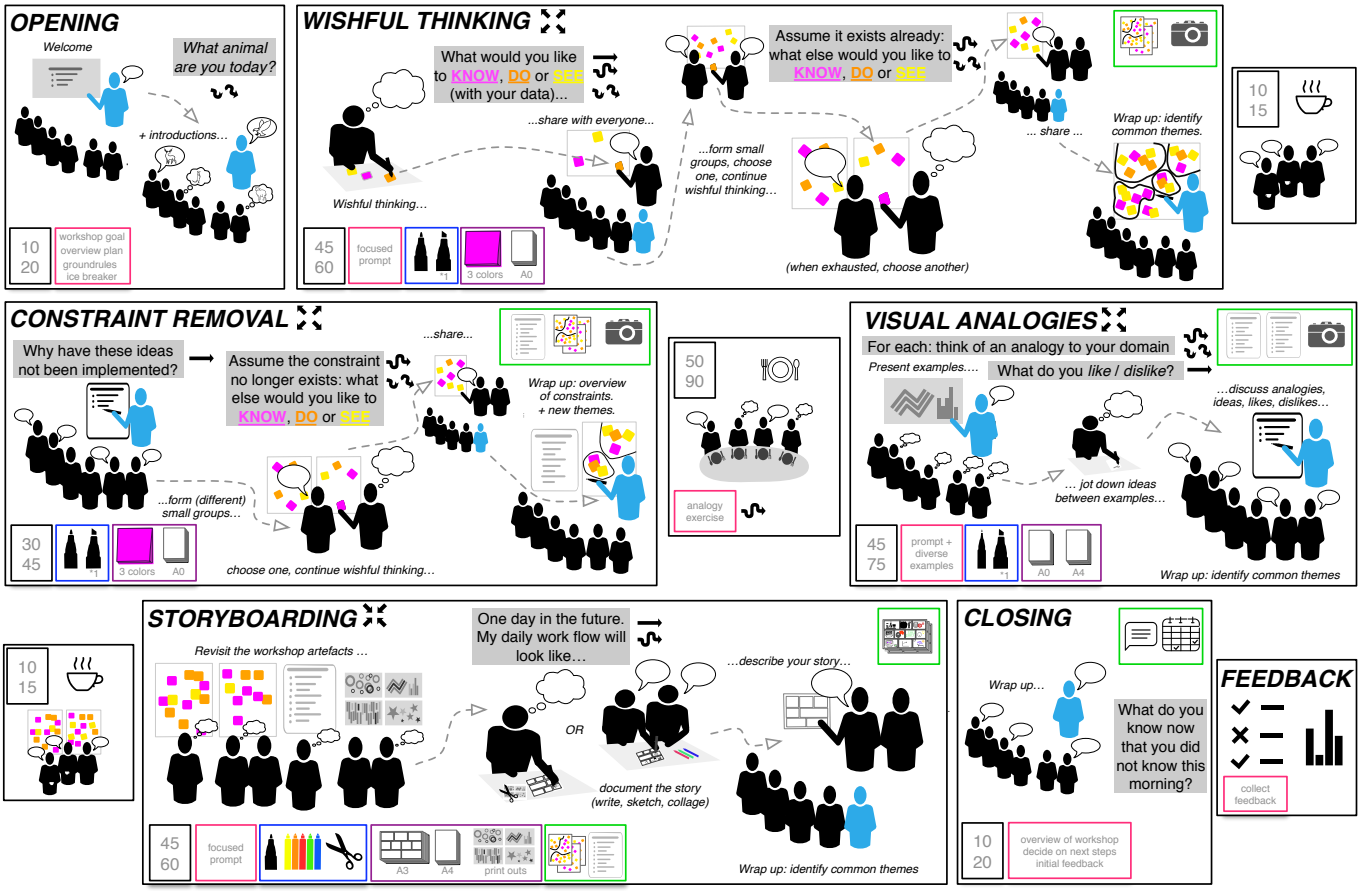

Fig. 3. Overview of a full day requirements workshop with methods of: opening, wishful thinking, constraint removal, visual analogies, storyboarding, and closing. For each method we identify the concrete aspects—components, process, and duration. We also characterize the intended creativity as paradigm preserving, breaking, or bending. A full description of the workshop will be included as supplemental material. <E: This figure will likely be supplemental material too, depending on available space.>