Advancing Visual Design Culture in STEM Lab Groups

Vassilissa Semouchkina

A thesis submitted in partial fulfillment
of the requirements for the degree of

Master of Design
University of Washington
2021

Committee:
Karen Cheng
Kristine Matthews

Program authorized to offer degree:
School of Art + Art History + Design, Division of Design

University of Washington

Abstract

Advancing Visual Design Culture in STEM Lab Groups

Vassilissa Semouchkina

Chair of the Supervisory Committee:
Karen Cheng
Professor
School of Art, Division of Design

There are pervasive issues in scientific communication. Intervening at the level of the STEM (science, technology, engineering, math) research laboratory presents opportunities to observe and evaluate the existing visual design and critique cultures of these spaces. This data can be used to inform the creation of designerly tools specific to the needs of scientists. This thesis proposes the creation of custom, intuitive resources for scientists to promote continuous self-learning in visual design and critique.

Advancing Visual Design Culture in STEM Lab Groups

Vassilissa Semouchkina

Contents

Summary

One of the most common tasks facing academic scientists is the communication of scientific information, however, this essential research risks being obscured or misunderstood due to poor visual communication. This thesis explores methods for improving the level of visual design and critique practiced in STEM (science, technology, engineering, and math) research laboratories. This study was done in two parts: 1) conducting research on whether practicing critique enables scientists to improve the overall quality and communicative value of their visual work, and 2) creating a physical toolkit of various design and critique-centric materials tailored to scientists and their visual design needs.

I began this process by conducting a literature review and interviewing experts and professionals in the field of scientific communication. At the same time, I was reaching out to several labs across the University of Washington campus to begin observing their group meetings—this would allow me to measure the existing level of visual culture in the labs. Following several months of observation, I conducted a pair of workshops with each group, with the first workshop focusing on visual design basics and the second on practicing visual critique. Before the first workshop, students were asked to fill out a survey that measured their baseline understanding and comfort level with visual design and critique, as well as their ability to provide critical feedback for a set of five scientific figures. After the workshops, students were given a similar survey in order to determine if their skills had changed.

During the surveying process, students were also asked about which areas of visual design they were especially interested in, what they thought was most important, as well as what still seemed confusing. This information was used to create a Researcher's Toolkit for Visual Design and Critique—a selection of engaging educational booklets, guides, and checklists meant to help scientists learn, practice, and maintain visual communication and critique skills.

After sorting through the information gathered from the surveys, a series of spreadsheets was compiled to allow for easier evaluation of any trends in the data. The students' answers were then coded against a set of professional designers and scientific communication specialists' answers in order to set a standard for high-level design feedback. This data, as of now, is being used to write a research paper on how the quality of researchers' visual feedback changes after engaging in visual critique with laboratory peers.

Exhibition at the Henry Art Gallery

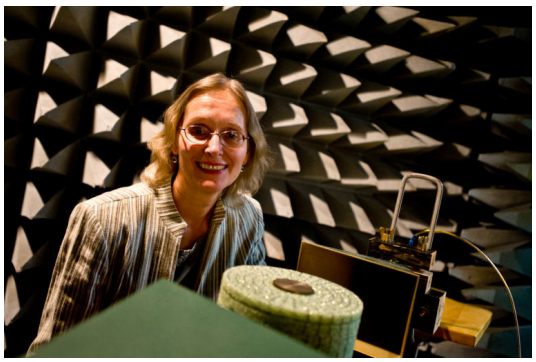
Preface

I have always been surrounded by science and academia. My grandparents were professors and engineers, all but a few of my relatives are faculty, and my parents—well, I'm sure you can guess that they followed a similar track. When I began my undergraduate career, I initially took a different path. I'd spent my youth obsessed with the arts and landed on wanting to be a graphic designer.

I started my undergraduate program at the University of Michigan, and I was so excited to begin a journey in this new, unexpected direction—that is until, well, I got bored. There's absolutely no issue with pursuing a singular degree in design, but after spending my entire life immersed in the sciences, I felt that there was something incomplete about my education. I pursued a second degree in architecture, hoping to fulfill what I was missing through what I saw as a more technical, human-centered design practice.

After graduating, I took a chance on a job as a designer and scientific communication specialist for Michigan Technological University, a leading R2 research university. In this position I discovered a fascinating and relatively unexplored intersection between design and the sciences—a problem area ripe for exploration that I took with me when beginning my Master's degree at the University of Washington. All that to say, I have spent my life immersed in the scientific community, and though my own academic interests took a different turn, I continued wanting to be involved in the sciences as much as possible.

There was just one problem. In my childhood, while my parents and relatives took the time to help me understand their work, drawing out explanatory diagrams and schematics on napkins at the dinner table, when I would tag along on academic conferences, it was like walking into an intellectual brick wall. The posters, the presentations—nothing made sense. Nothing, from what I could see, communicated.



Dr. Elena Semouchkina in an anechoic chamber

Vassilissa and her family in the early 2000s

Background

Clearly, there are issues with scientific communication, and unfortunately, these issues are widespread. Not only do researchers have trouble explaining their work to their own communities (Feliú-Mójer, 2015), but poor communication is also a factor in the growing public distrust of science (Burdick, 2018). I experienced this firsthand when working for the aforementioned STEM university, which boasted an impressive research reputation while being nestled in a remote, rural community. The population there was like a microcosm of American society. While at my job, I was constantly surrounded by scientists and their essential, innovative work, however, in leaving campus and interacting with community locals, there was a disconnect. Many so-called "townies" didn't understand, trust, or even believe in the science that was being worked on just blocks away from their homes.

I was fascinated and perplexed by this problem space, however, this issue is much bigger than any one-year-long thesis can tackle. Breaking the problem area into individual factors helped reveal smaller problems that were more realistic to tackle and could result in positive change. More specifically, I became interested in a setting that was central to the process of generating scientific data—the research lab. Students in research labs are expected to communicate their work by producing visuals for presentations, journals, and conferences. Scientific visuals are critical components of research, helping clarify or strengthen arguments that might otherwise seem abstract (Frankel & DePace, 2012). When submitting a scientific paper to a journal, visuals and figures are often the first parts the editors review. If the paper is then accepted, figures are once again one of the first items examined by academic peers (Rolandi et al., 2011). However, the students in these research laboratories seldom receive any formal training in visual communication design, having to learn visual skills and software in their own time instead (Clarkson, 2014). This results in the creation of scientific visuals that do not adequately communicate their purpose.

I'm not the first to notice this problem. Many universities and communication specialists focus on bettering scientific communication—there are workshops (Clarkson, 2014), online resources, classes, and even help desks (O'Mahony et al., 2019) available to assist researchers in creating better scientific graphics. Clear, informative visuals are a tried and tested pathway for furthering accessible, memorable scientific communication—we associate many of the most profound ideas in modern science with corresponding visuals, from Crick's DNA Double Helix to Mendaleev's Periodic Table. However, despite widespread agreement that visual communication can be essential to advancing science, the overall level of visual design in scientific communication (i.e., in figures, posters, and presentations) remains relatively low.

While several solutions have been proposed to enhance visual design culture in the sciences, I believe these approaches were limited and short-term. I propose focusing on long-term learning and retention by educating researchers to practice visual critique alongside learning basic visual design principles. In design education, critique is essential in teaching students how to reflect on and improve their visual work. Dannels and Martin suggest that creating similar feedback cultures can be just as effective in other professions. (Dannels & Martin, 2008) In addition, I argue for the creation of designerly tools specific to the needs of scientists to better tailor and make accessible the visual design and critique-related information most relevant to them. Through my research, I intended to explore: 1) what about visual design and critique scientists find most helpful and relevant to their work, as well as how design materials might then be created to specifically suits the needs of scientists, and 2) whether or not a scientist's baseline ability to distinguish and identify design problems increases through engaging in and practicing critique.

Vassilissa leading a visual design workshop

Research

I conducted primary and secondary research through: 1) reading academic literature and related research, 2) participating in expert interviews, and 3) meeting/observing four research laboratories several times weekly from October 2020 to January 2021.

Literature Review

To gain a better understanding of the breadth of existing research on scientific communication, I read a variety of related theoretical and research-based literature on the intersections of science and visual communication design, critique culture, and public perceptions of science.

To begin, I looked into studies exploring various methods of teaching visual design to scientists. Clarkson conducted workshops with researchers to show how even moderate training in design can lead to an improvement in how they approach design tasks (Clarkson, 2014). However, while the success of these workshops is noteworthy, these exercises are short-term and occur in isolation. As a result, it is hard to determine if there was any long-term retention of visual communication design skills on behalf of the researchers. Another method of teaching visual design to scientists was to do so remotely (Ishizaki et al., 2008). More specifically, Ishizaki looked to provide resources for college students to self-learn basic design skills. While this approach helped make visual design accessible to a wider audience, the content of the tutorial was optional and only offered in the short-term. In addition, having a set tutorial, while effective for promoting self-learning, limits opportunities for continuing education and practicing one's design skills.

There were also recommendations to partner scientists and designers in order to create effective visuals (Khoury et al., 2019)—a process I was quite familiar with from my own experience working with researchers at Michigan Technological University. While this approach resulted in the highest quality of scientific visuals, it can be difficult to sustain. With so many researchers in need of visuals, how would universities meet the demand? And from the perspective of the designer, how many would be willing to skirt away from more traditional design jobs?

A potential solution to these questions was the University of Washington Design Help Desk, a physical help desk staffed by designers and open to any students, faculty, and staff looking to improve their visuals (O'Mahony et al., 2019)—I myself spent my thesis year working there. However, while the Help Desk is a popular resource, access is limited to the University of Washington, and issues with supply and demand remain if the Help Desk becomes more popular. In addition, while researchers are able to receive

design advice through the Help Desk, this advice is often limited to a specific project and doesn't specifically promote learning on behalf of the researchers.

I also investigated existing research on using critique as a method for practicing and learning visual design skills. Feedback culture is almost synonymous with design education, being one of the main ways that designers learn to identify problems in both their own and their peer's work (Dannels & Martin, 2008). Design knowledge, rather than being passed on through lecture, is often communicated from instructor to student through critiques (Uluoğlu, 2000). Both in and out of design education, involving students in self and peer-assessment promotes inter-group discourse and allows for students to better self-identify problems in their own work (Kearney, 2013). Considering these findings, it can be inferred that groups external to traditional design education, such as scientists, could benefit from engaging in visual discourse like visual critique. Practicing visual critique also has the potential to elevate and advance the participating scientist's visual design skills.

Conducting a literature review of the topics surrounding scientific communication and critique enabled me to better understand the problem space and the previous efforts made to resolve pain points. The various data-gathering processes of other researchers working in this area helped me contextualize and bring forward methods for addressing my research questions, as well as consider progressive new solutions to scientific communication problems.

Primary Research through Interviews with Scientific Communication Professionals

I conducted expert interviews with various researchers and professionals who participated in scientific communication training or educated others on the subject. This included a former Rice University visual communication and design instructor, an experimental physicist who specialized in creating scientific visuals for STEM researchers, and a post-doctoral researcher investigating climate change who had taken visual design courses and organized workshops on design and science. These interviews gave me further insight into the current status of scientific communication education—most significantly, what visual design-related resources were popular in the scientific community, which research laboratories to connect with for my research, what approaches to scientific communication have and haven't worked in the past, as well as what potential solutions might be more effective than others.

Primary Research on Current Visual Design Culture in Research Laboratories

The research laboratory was the primary setting for conducting my research. In order to survey the existing level of visual design culture in various laboratory environments, I connected with four laboratories across the University of Washington campus, which focused on biochemistry, ecoclimate, bioengineering, and chemistry research. Most labs met weekly, with the exception of the bioengineering lab that met every two weeks, and conducted sessions lasting between one and three hours. During laboratory meetings, I observed how laboratories operated, maintained their internal structure and hierarchy, and conducted both visual and content-based feedback sessions. These observations enabled me to form a baseline understanding of how and if laboratories practice visual communication design and critique, as well as form a working relationship with the students and principle investigators [P.I.s]. The observation sessions began in October 2020 and lasted throughout May 2021, concluding when I entered the final month of the thesis process.

In addition to the four labs, I also occasionally observed a design course focused on introducing non-majors to introductory principles of visual design to see what early design lessons are most important and effective.

The Labs

The labs and communications course involved were as follows:

The Engage Seminar: a science speaker series and seminar focused on training graduate students communication skills in order to help foster public understanding of the sciences.

The Averkiou Lab: a biomedical science lab focused on developing imaging and therapy ultrasound technologies in order to bring image-guided ultrasound-mediated drug delivery in clinical trials.

The Pun Lab: a bioengineering lab focused on developing bioinspired materials to advance drug delivery and molecular imaging technologies, utilizing techniques from engineering, chemistry, and cell biology.

The Cossairt Lab: a synthetic inorganic chemistry lab focused on building up inorganic nanostructures for targeted applications in light emission, energy harvesting, and catalysis.

The Swann Lab: an ecoclimate lab studying how plants and climate interact with one another by understanding the physical climate system and the underlying biological process that govern ecosystems and characterize their response to environmental variability and change.

In observing the Pun Lab, Suzie and I talked briefly and I mentioned how thankful I was to attend the lab session. Suzie acknowledged this and thanked her students as well, and then mentioned that she would introduce me once all the students came in. Everyone filtered in and Suzie proceeded to give me an intro, after which I introduced myself and my work more thoroughly. In essence, I said that my thesis looked into critique culture within laboratories, both general and visual. The students did not seem affected, as there were only two, but they appeared welcoming. Suzie then called upon Alex, the first student, to present. Alex opened up with a clear explanation of his work, and a slide that featured a hand-drawn graphic with interesting colors. Right away, his presentation had an 'aesthetic' - it was purple themed and had consistent text. Alex made it clear that he was focusing on polyphenols, and moved into a slide that had transitions, but was pretty overwhelming - it had both images, graphics, and charts which were severely filled with information. It looked as though he was using the images in place of bullets, instead of having them actually communicate his information. Alex continued using transitions, with images appearing on slides in the order that he was speaking. Certain slides appeared more open than others, letting the information flow more smoothly. While many images and graphics looked to be generated by a program or were stock photos, it was clear that Alex drew and illustrated some of his visuals in his purple color scheme - a nice touch. Alex did speak extensively over some slides, often hanging on a single slide for two minutes at a time while covering dense information. Overall, Alex's presentation was easier to understand in the beginning, where he had more clear explanations and used imagery to prove his points. It got a bit heavy and clogged towards the end,with the images becoming less instructive and more specifically nuanced - which was expected in an advanced laboratory environment. Alex also used icons - I wonder where he got them - to explain some processes in order. This is good intuition, but the icons were chaotic and looked to be taken from different sets. In general, it did appear that Alex was trying to use visuals instead of text in order to make his presentation more palatable, but it still felt inconsistent, hard to follow, and unbalanced from an external perspective. However, Alex's understanding of white space was great and the consistency of his type and 'brand theme' was great. After his presentation, questions and comments followed, but there were more towards the work itself - there weren't really any comments on his visuals. Next up was Audrey, another of Suzie's students. Audrey began her presentation with incredibly complex language, and right off the bat her research was hard to follow as someone outside of the lab group and profession. She did use a similar color scheme to Alex, and primarily focused on consistently colored 3D graphics. After her initial and confusing pitch, Audrey moved on to an 'introduction' of sorts, where her language became a bit more clear - ah, yes, she is focused on tumors and how we might better deliver drugs to them. Her visual language remained pretty consistent, a mashing together of teal, grey, and purple - impressive! However, a designer could still easily tell Audrey is not classically trained - but the intuition is there. Audrey's use of white space was good - her figures breathed on her pages for the most part. Occasionally, she would throw in a 2D element, but it would have a 3D nod (like a realistically shaded rat). However, a disclaimer that, like Alex, Audrey also often talked over her visuals without necessarily using them as a communicative asset - these were data visualizations, but not necessarily successful

Coded Laboratory Observation Document

While these were the primary research laboratories I worked with in terms of both observation and conducting eventual visual design workshops, I was also contacted by an additional lab, The Molecular Biophotonics Lab, and class, BIOEN532: Professional Skills Development. I was unable to establish a prior observational relationship with either group, as they contacted me for the sole purpose of conducting a pair of visual design-related workshops. Additionally, I wasn't able to use the data from these sessions for the following reasons: 1) the Molecular Biophotonics Lab talks were extracurricular, leading to low and variable attendance (i.e. most students only attended a single workshop), and 2) BIOEN532: Professional Skills Development only received the first workshop due to time constraints.

Initial Research Findings

In conducting primary and secondary research through literature reviews, expert interviews, and laboratory observations, I gained significant insight into the world of scientific communication, as well as researchers' interests, opportunities, but also pain points with visual design. I then used this information to help frame and tailor the content of my future visual design workshops. To begin, I will discuss the findings that highlighted a desire on behalf of the researchers to learn visual design skills as well as opportunities for intervention. These findings are as follows:

1. Many researchers are openly interested in visual communication. They want to be able to talk about and improve their visuals and graphics, but often lack the skills to do so. And while there are some existing resources available, most researchers don't seem aware of them. The availability of these resources is not adequately communicated to them, and even if researchers do find ways to participate, there are often no follow-up sessions or ways to assist them in retaining learning.

2. When researchers present, they rely almost exclusively on graphics and diagrams to explain their work. There seems to be a general consensus across labs that having a wall of text is an inadequate way to communicate research findings, meaning that figures and visuals are most often used as placeholders for detailed talking points or text. Most P.I. and peer feedback on presentation slides is centered on elaborating on the meanings of different visuals, as presenters appear to gloss over figures without discussing their intent. Because the figures or visuals are often inadequate at communicating their purpose independently of a verbal explanation, this suggests that the graphics are not effectively helping the researcher as a visual aid.

"Often I've been staring at [my figures] for so long, I think what they're showing is super obvious, but nobody else has any idea what I'm talking about."

–Lab Student

While some findings indicated a straightforward need for scientists to learn visual communication design skills, pain points also highlight important spaces for consideration, improvement, and intervention:

1. Overall, researchers hope to find 'quick fix' solutions to their design problems. They often don't have the time to commit to extensive extracurricular training or devote multiple hours to redoing an existing visual. Most researchers don't seem interested in learning basic design theory or more open-ended solutions to design issues. Instead, there seems to be a general preference towards being told what they can do to ensure consistently successful visuals. Researchers lamented the lack of targeted, simple-to-follow materials such as checklists and instruction sheets for improving visual designs quickly and without significant effort.

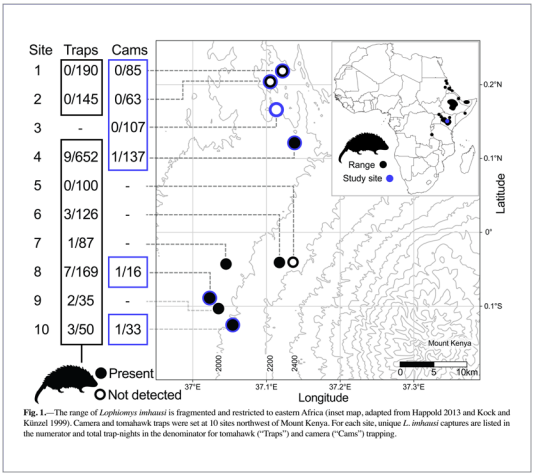
2. While most researchers appear to know that visual design and the communicative qualities of their work are important, they don't seem to know how to best put this understanding into practice. More specifically, while researchers understand that the quality of their scientific visuals can and should be improved, they do not have the skills or awareness of how to fix them or identify specific problem areas.

3. When P.I.s and students often veer towards dedicating a single lab meeting for discussing revisions and improvements to their visuals, with the session usually lasting between 1-3 hours. These short-term sessions, while still helpful, are not conducive to the multi-stage 'revise-and-review-again' feedback process that is considered essential to creating effective and well-rounded visuals.

4. Not only are these often-solitary visual feedback sessions not able to accommodate multiple revision cycles, but they are often held close to submission deadlines for journals, posters, and presentations, rather than being integrated throughout the scientific process. There is seldom any continuous discussion of visuals or critique process sustained during regular lab meetings, although frustrations with the clarity of text and graphics are often brought forward by both students and their P.I.s.

5. When labs do review figures with the intent of improving them, the designerly elements of the graphic are seldom the focus. Most critiques concentrate on the written content, making sure that figures show all necessary information and intended concepts. While this may seem like a move in the right direction, most P.I. and peer suggestions focus on packing a figure with extra information, leading to design issues such as over-complication and overcrowding. Issues like these could be mitigated by breaking a single graphic into a series of related, but separate, figures, or perhaps utilizing visual elements to explain complicated concepts that would otherwise be contained in text.

Observing these labs and offering advice on their visuals over the course of several months allowed me to build a working relationship and rapport with the students and P.I.s and enabled them to behave more naturally around me. After observing the labs over the course of several months, I prepared a pair of workshops to introduce the labs to visual communication design and critique basics, as well as measure their baseline understanding of these practices. Considering my overall research questions, I hoped to use these workshops as a way to determine what elements of visual design are most specifically helpful to researchers, as well as which particular lessons are most effective and result in the most information retention. These workshops were also important as a way to measure whether going through a critique process positively impacted the quality of the user's design work. When asked, all groups were receptive when I proposed using lab meeting sessions to teach a pair of visual design and critique workshops. In addition to the workshops, it was important to survey the students to get a more concrete understanding of their baseline and post-observation experiences, resources, knowledge, and comfort in using visual communication principles and practicing visual critique. These surveys would also help me determine if the workshops themselves were successful and effective. The overall insights from the workshops and surveys would inform two potential approaches to my research questions. The first was a scientific communication toolkit meant to help researchers self-teach themselves visual design methodology as well as learn the importance of and practice critique. The second was a research paper documenting whether or not practicing critique helps teach and enforce visual communication design skills.



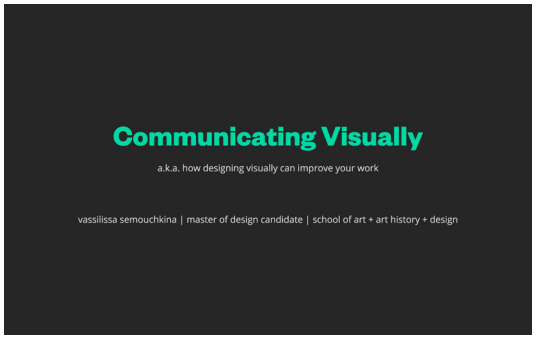
A scientific figure from the surveys (Weinstein et al., 2020)

Workshops + Surveys

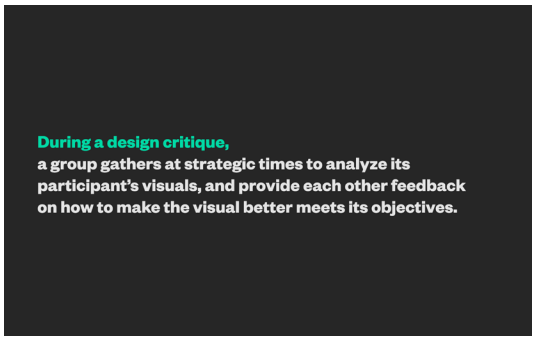
During the fall and winter academic quarters, the focus of my work was gathering insights and conducting research on what about visual design and critique scientists find most relevant and helpful to their work. During the spring quarter, I would then use this data to create an effective and desirable scientific communication toolkit to help scientists self-teach and maintain visual design skills, as well as begin work on a research paper discussing the effectiveness of practicing visual critique in research laboratories. Some of the main areas of concern I hoped to address were what areas of design or specific materials researchers were most interested in improving, what material resources they would find helpful or desirable, and what aspects of visual design they found most confusing and difficult to retain. This process consisted of hosting the aforementioned visual design and critique workshops with the research laboratories, as well as conducting surveys with and gathering a selection of figures from participating groups. Below, I elaborate on the reasoning behind each of these steps, and how their results inform the rest of my thesis process.

Workshops and Pre-Readings

After conducting primary and secondary research on the issues and points of intrigue surrounding scientific communication and the efforts that have been made to improve it, as well as building a working and observational relationship with several labs across campus, I ended the fall quarter by organizing a series of design workshops with these labs that would occur between February and April 2021. These workshops would consist of two separate sessions and introduce the labs to both foundational design principles as well as visual critique theory and practice. In addition to assigning visual homework tasks like redesigning their own figures, having the workshops in two sessions prompted the students to engage with visual design learning over a longer span of time. Before the workshops, students were given a survey to complete and asked to submit a scientific figure, preferably their own, that they would like to improve. They were also given a reading, Alberto Cairo's The Functional Art: An Introduction to Information Graphics and Visualization, Chapter 6: Visualizing for the Mind, which briefly discussed the importance of visual design principles and how small adjustments to a design can lead to significant improvements in overall visual clarity. They were also asked to watch a short video, Scott Berkun's Feedback Without Frustration, which covered the importance of practicing visual critique, as well as some of the associated issues and frustrations involved and how to overcome them.



First slide of the visual design workshop presentation



Slide from a critique workshop presentation

The Visual Design Workshop: This 1-hour workshop centered on how advancing visual communication skills can help researchers improve and make clear the meaning of their scientific visuals. This was accomplished through exploring various visual elements, as well as arranging, composing, and drawing attention to these elements. We began with a lecture on the place of visual design in the sciences—in this case, visual design was described as a mechanism to enhance the communicative ability of visual scientific work. The workshop went on to introduce and cover the foundational elements of visual design in the following order: contrast, hierarchy, space, proximity, unity, flow, and color. After defining and exploring a foundational principle, the students were shown an example of a scientific visual before and after it was improved through the application of the discussed design principle. After showing the first scientific figure, students were asked to offer feedback on how the figure could be improved in order to make it more clearly communicate its message. The next topic covered was layout, where we discussed what to keep in mind when considering the design of backgrounds, text, image placement and selection, and whitespace. After this section, the students practiced applying the various visual design principles we had covered earlier in the workshop—specifically, I showed them three additional scientific figures, with blunders ranging from easy to difficult to identify. The students then offered their feedback on what could be changed in each figure to make it more clear before being shown the improved version. Following this, I conducted a brief discussion of visual critique, which acted as a prelude and introduction to what would be covered during the second workshop. The workshop finished off with assigning homework—specifically, the students were asked to make sure they'd read the Cairo reading and watched the Berkun video assigned before the start of the workshop in preparation for the second session. The students were then given a visual design "cheat sheet", which I will discuss more further, to help them remember the various visual design principles, as well as offer hints for initiating and practicing design critiques.

The Critique Workshop: This 30-minute workshop centered on the benefits and process of visual critique. This workshop first covered what design critique is and how it could be a critical and easily introduced step in STEM labs for improving scientific visuals without the presence of a design professional. We began with an overview of what visual critique is—specifically discussing how during a critique, a group gathers at strategic times to analyze participant's visuals and provide each other with feedback on how to make the visual better meet its objectives. We then moved on to discuss the importance of design critique, as well as what visual critique entails. I made sure to discuss the differences between virtual and live critique, as our workshop was taking place during the COVID-19 pandemic and would exclusively involve the former—this would help ensure that students would also understand how to practice live critique after the conclusion of the pandemic. Following this, the

students were encouraged to begin each critique by selecting a group leader to moderate the session. They were also advised to discuss and set critique goals, which are a series of project-specific objectives that help participants direct and target their feedback. We moved on to discuss various important points to keep in mind when getting and giving critique, before moving onto the critique itself. The majority of the workshop focused on a peer critique of the student's submitted figures from the previous session, during which students could reference their design "cheat sheets" in order to better focus their suggestions. Following the workshop, students were asked to consider their peers' advice and submit a reworked figure in two weeks' time.

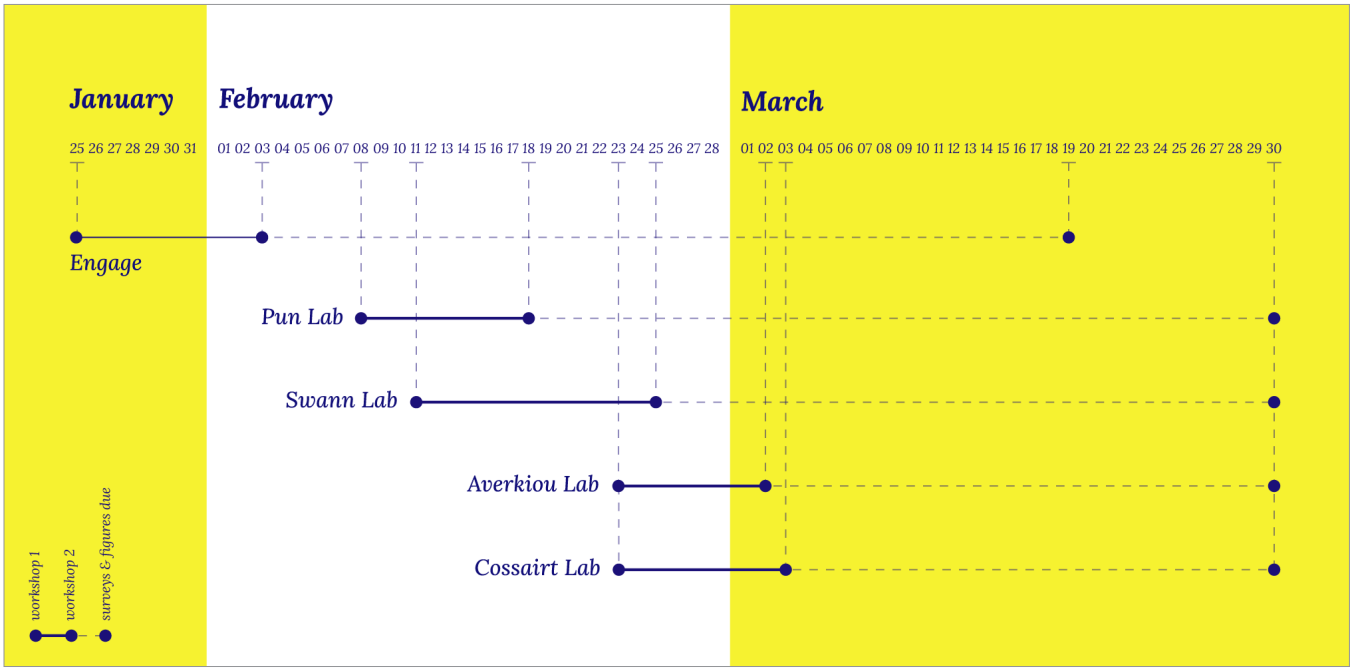
Cheat Sheet

Between the main and critique workshop, students were given a visual design cheat sheet to help them during the critique session of the second workshop, as well as for general use when improving their own figures. This cheat sheet offered reminders on how to structure and conduct critique sessions, as well as an overview of the visual design principles covered during the main workshop. The cheat sheet consists of four pages: an introduction to visual critique and how to use it, a summary of critique structure and template for listing critique goals, a page for the participant to evaluate their own work, and a page briefly covering the elements of visual design.

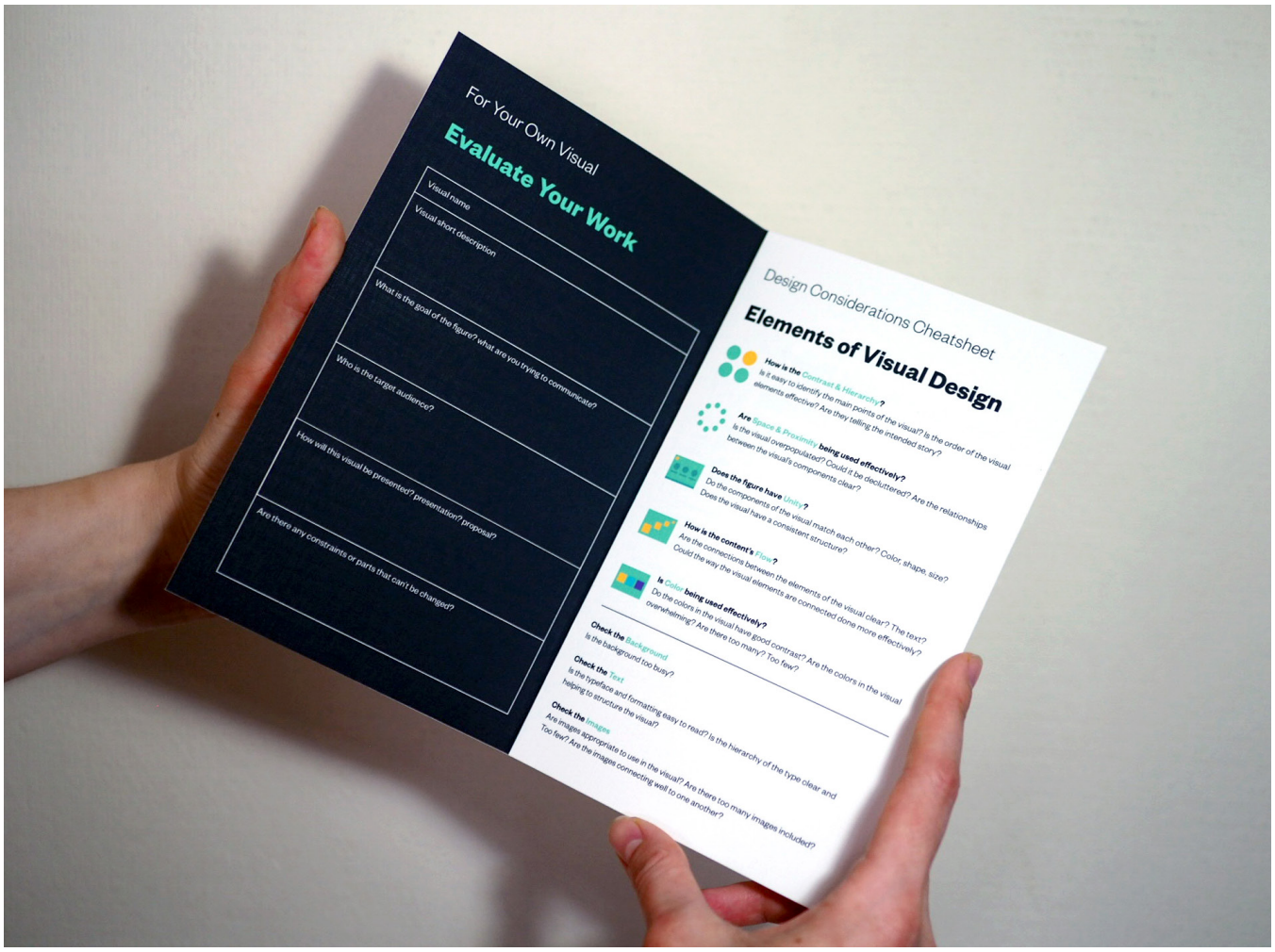
Surveys and Figure Submission

While the workshops were the primary way to directly engage the laboratories in visual critique and discussion, the labs were also provided with a series of surveys in order to measure their understanding of visual design before and after the workshops, as well as evaluate the success of the workshops themselves. A section of the surveys also asked participants to submit any scientific figures they'd like to develop or improve further.

Pre-Workshop Survey: This survey was given to participants a week before the main workshop. The survey gathered and documented the participants': 1) general background information and academic rank, 2) current utilization of and experience with scientific figures, 3) knowledge of visual design, 4) training in visual design, 5) opinion of what makes a successful figure, 6) a personal assessment of their own visual design skills, as well as other important foundational information. In addition to these more personal and opinion-based questions, participants were given 5 pre-selected figures to visually assess and critique, in order to measure the quality of their comments and understanding of design flaws before being introduced to foundational design theory. As mentioned above, they were also asked to submit any scientific figures, preferably their own, that they believed could be improved.



Timeline of visual design and critique workshops



Elements of Visual Design Cheatsheet

"I found the critiques received from my lab members the most relevant and helpful with my own work. In addition, I felt that having some guidelines on critiquing others as well as how to ask for critique from others was also helpful."

–Lab Student

Post-Workshop Survey: This survey was given to participants directly after the conclusion of the critique workshop. The content of this survey mostly matched that of the pre-workshop survey to document variances in participants' responses before and after the workshops. While both the pre and post-workshop surveys were intended to be anonymous, participants were given identity 'tokens' to match pre and post-workshop survey results. The information regarding who was given which token was destroyed after the conclusion of the workshops.

Cheat Sheet Survey: This survey was given to participants a month after the conclusion of the critique workshop. This brief survey asked participants if they had been using the visual design cheat sheet since the conclusion of the workshops, and if so, what about it the cheatsheet found helpful, as well as what they thought might improve the cheat sheet and make it more desirable for future use.

Figure Submission: Figures were collected from the workshop participants in two parts: 1) before the main workshop, and 2) two weeks after the conclusion of the critique workshop. The first figure collection was done before the workshops in order to gather unedited, 'baseline' figures from the participants. After going through both workshops, participants were then asked to rework and resubmit their improved figures, with the expectation that these would be somewhat improved and easier to understand.

Organizing The Data

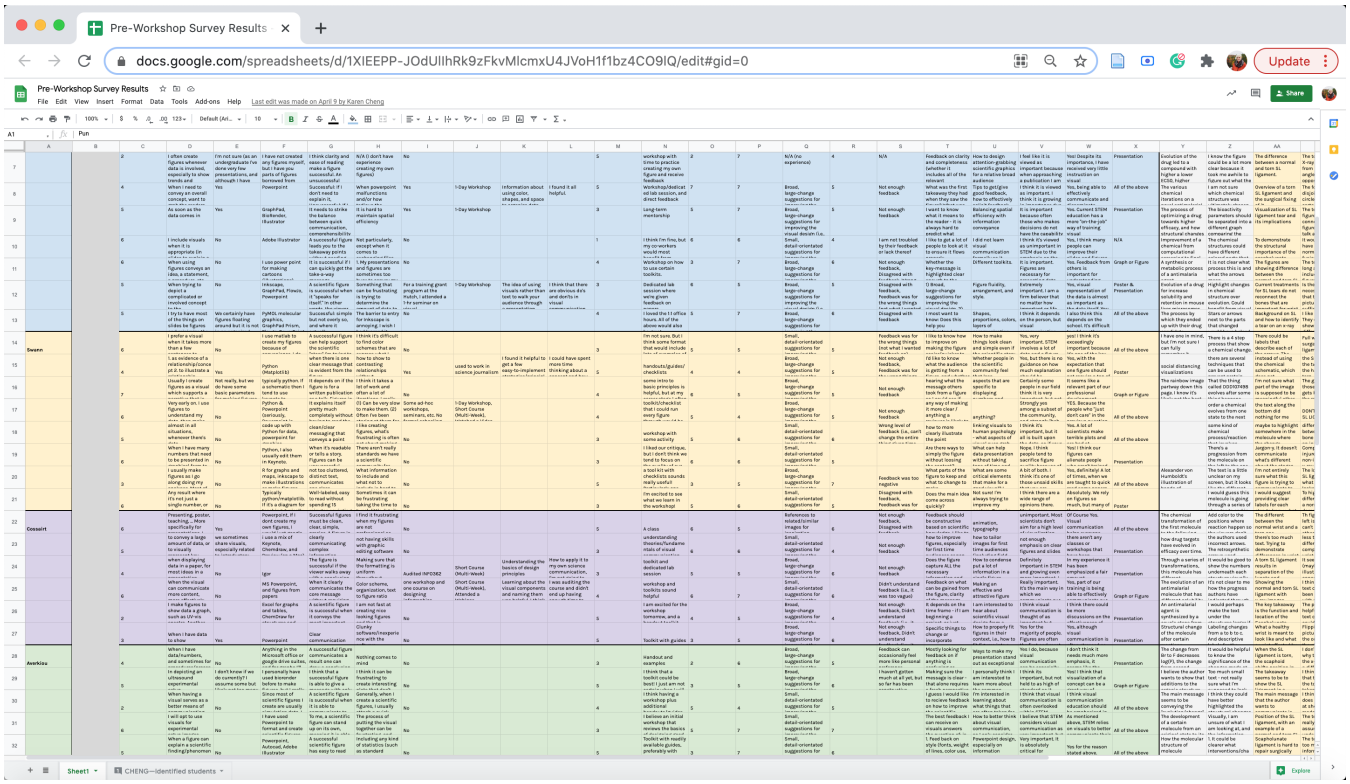
Following the workshops, the data received from the before and post-workshop surveys was organized in order to better visualize the differences between initial and new answers. This was done by compiling survey answers from each lab into a 'before workshop' and 'after workshop' spreadsheet, and color coding the answers according to lab and question type. Sorting the questions in this manner helped to identify positive or negative trends in the data. Specifically, I hoped to observe if: 1) there was any change in the student's personal evaluation of their understanding and comfort with visual design and critique, 2) what about visual design and critique the students found most relevant and helpful, as well as what they wished to learn more about, and lastly 2) considering the 5 figures at the end of the survey, if there was any discernible change in the quality of the student's feedback.

In addition to written answers, the student's submitted scientific figures from before and after the workshops were compiled in order to evaluate change. While the surveys primarily focused on highlighting changes in the student's verbal skills, it was also important to evaluate if there was any improvement in the overall communicative and visual qualities of their submitted figures.

The insights from the surveys would be used to help answer the research questions of this thesis and inform the creation of the aforementioned visual design and critique toolkit, which would act as a resource for scientists to help self teach and maintain visual design and critique basics, as well as inform a publication on the results of the workshops—this will be addressed further below.

Blunders

I should note that while overall the surveying process went smoothly, I did encounter a significant blunder. Because both the pre and post-workshop surveys were meant to be anonymous, there needed to be a way to connect the results of the first survey to the second, such as an identification token. When conducting the initial post-workshop survey, I failed to account for this token, and as a result, it was impossible to ascertain if students had improved their visual design and critique skills following the conclusion of the workshops. After fruitlessly trying to match results based on lab group and academic position, I had the labs retake a slightly modified version of the post-workshop survey, which now included an anonymized identification token.



Compiled pre-workshop survey responses

Toolkit

The content of the first set of materials in the Researcher's Toolkit for Visual Design and Critique was created from a mixture of insights from laboratory observations, workshop dialogues, and before and after survey answers. The purpose of this toolkit is to provide resources for scientists going through a visual design process and looking to improve their work. While these materials were created from the insights of researchers involved in the workshops, the toolkit is meant to be an easy resource for any interested party to pick up and understand, without needing any previous visual design training.

The toolkit will primarily be distributed digitally. It will be made available for free download at *researcherstoolkit.design* in order to promote greater access and distribution. Considering these constraints, all the included materials are designed to be printed on common academic paper sizes—specifically, 8.5x11" and 11x17". In order to increase appeal, the materials also needed to be simple to assemble, and easy for a user to carry with them. As such, all posters are true to size, and booklets can be created by folding, cutting, or manipulating single sheets of 11x17" paper. The materials in the Researcher's Toolkit for Visual Design and Critique include:

The Critique Poster: a bright, attention-grabbing poster meant to be hung inside active research labs. This poster covers important guidelines to remember when creating a critique group and carrying out a visual critique session.

The Figure Submission Checklist: a checklist of common mistakes to look out for when designing and preparing scientific figures for presentation and publication. This checklist is organized into sections to help scientists target specific problem areas and guide them through a revision process.

The Little Book of Color Theory for Scientists: a booklet containing essential information on several aspects of color theory, such as the color wheel, color harmony rules, printing conventions, and more.

The Little Book of Critique for Scientists: a booklet covering how to prepare for, start, lead, and participate in visual design critiques. This beginner's guide introduces the basics of visual design critique and provides an overview of how to introduce and cultivate a successful laboratory critique culture.

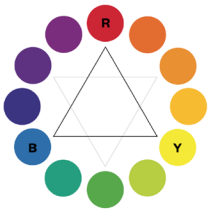
The Little Book of Visual Design Principles for Scientists: a booklet covering the basic ideas and foundational concepts of visual design, such as those covered in the first visual design workshop. The ideas discussed include contrast, hierarchy, proximity, continuation, flow, space, micro space, unity, and color.

The Little Book of Color Theory for Scientists

Color Wheel

Color wheels help show the relationships between colors. Using the color wheel can help create effective, harmonious, and contrasting color combinations.

The color wheel has three **primary colors** (red, yellow, blue), and the blending of these colors creates the full color spectrum. Blending primary colors together creates the **secondary colors** (purple, green, orange), as well as other colors.



Color Wheel

△ Primary Colors

▽ Secondary Colors

Hue/Value/Saturation

Hue refers to a true color – consider pure red, blue, yellow, etc. Hue does not determine whether a color is dark or light.

Value is the relative lightness or darkness of a color. A color's value is changed by adding white or black to a hue–however, the hue itself is held constant.

Saturation refers to the amount of pigment in a color–a saturated color will look bright, while a desaturated color will appear dull.

Hue

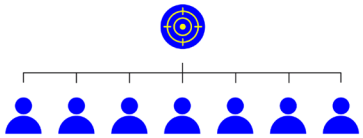
Value

Saturation

Before Critique

Before beginning a critique, have participants prepare all relevant materials and be ready to engage in discussion. A **critique leader** should be chosen to help direct conversations and keep them on track–this role can rotate each session. In addition, participants should be given a consistent format for displaying their designs–for example, should they be printed? Or displayed digitally?

Participants should consider and record their critique goals before the session. They should be ready to discuss both the goals as well as their overall project background, in order to give more context to the work.



Critique Leaders Ensure Discussions Target the Goals of the Critique

Critique Goals

Be sure to set personal and group goals for critique sessions. For example, if working on a series of figures for a publication, what should the group keep in mind when reviewing visuals? The audience? The journal requirements? In terms of personal goals, what might need to be changed to make a specific figure flow better, or show the meaning more clearly? This information also helps critiquers focus their feedback.

Before a critique begins, **participants should evaluate their own work.** Participants should come to the session prepared with the following information:

- **Name of the Design Being Reviewed**
- **The Goal of the Design**
- **The Target Audience**
- **How the Visual Will Be Presented**
- **Constraints That Can't Be Changed**

The Little Book of Design Critique for Scientists

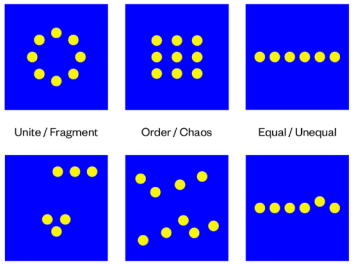
The Little Book of Visual Design Principles for Scientists

Proximity

a.k.a. deriving meaning from the location and placement of elements.

Taking care to position the elements in your designs intentionally helps prevent the viewer from making unintended conclusions and helps clarify your narrative.

The proximity of visual elements relative to each other communicates their relationship:



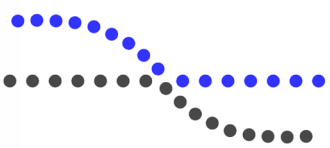
Unite / Fragment | Order / Chaos | Equal / Unequal

Continuation

a.k.a. using visual cues to guide a viewer's eye in a certain direction.

According to the Gestalt Law of Continuity, the human eye will follow the smoothest path when viewing lines, even if variables are changed to prevent it from doing so.

Below, note that the eye will follow the straight line into the curved line first, despite the color shift indicating that you should follow the lines designated by color instead.



Covers and pages from various booklets in the Researcher's Toolkit for Visual Design & Critique

Reflection

With my thesis process coming to a close, I discuss my findings and consider further obstacles and opportunities in my research process. While the overall flow of my thesis was smooth, as with any research process, pain points that I'd previously not accounted for became apparent and merit extra discussion and reflection.

Long-term Retention

After conducting workshops with various labs and analyzing the results of the surveys, I anticipated not seeing significant changes in student's skill sets over the course of what equated to an hour and a half of visual design learning. This initially led me to question whether or not the results of my study were truly impactful or rather temporary and forgettable skills. If it were possible, it would be better to survey students a few months after the conclusion of the visual design workshops, to see if skill and retention had improved, stayed the same, or dropped. However, while I consider this an issue worth investigating, it is important to note that the workshops, while valid in their own right, were a tool for gathering relevant data. Workshops are a tried and tested method for teaching scientists visual design (Clarkson, 2014), but with no way to enforce continuous practice bear the risk of short-term knowledge retention. While I created these workshops to be as beneficial to the laboratories as possible, my overall pursuit was auxiliary to the workshops themselves—more specifically, locating the areas of visual communication design that are most relevant and important to scientists, as well as evaluating if visual critique is an effective method for practicing and retaining visual design skills.

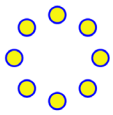
Toolkit Distribution

One of the major goals and products of my thesis was the creation of the Researcher's Toolkit for Visual Design and Critique. While the base materials of the toolkit are complete, I struggled when considering methods for making these resources widely available to scientists. When pitching the toolkit to my committee, widespread accessibility was one of the major selling points. During the surveying process, I asked the laboratory students their thoughts on how to address this issue, but beyond suggestions such as distributing physical toolkits at conferences or hosting the materials on a website, I didn't gain any particular clarity on this issue. While the creation of an independent website would be relatively simple, it would also render the toolkit anonymous, as scientists wouldn't have a way to know about the existence of the resource. My thesis chair, Karen Cheng, proposed an interesting solution to this issue which I am currently working towards—that is, hosting the toolkit on both

Good Figures Come From Good Critique

Ground Rules

Ideal Critique Size



Host critiques with **3-7 people** for the most productive conversations. Remember to designate a **critique leader**, who will keep things moving.

When To Critique

Organize **3 critique sessions** per project, such as an early, middle, and late review. For every critique, review and refresh the **critique goals.**

How Long To Critique

Critique for **5-10 minutes** a person. For a small project (like a figure), 5 minutes is fine. For larger projects, consider longer critique times.

Before Critique

1. **Set goals for and target critique sessions.**
   What are 3 or 4 goals for the project, and what should be discussed first? Last?
2. **Plan the quantity and length of critique sessions.**
   How long should each participant be critiqued? How many critique sessions should be scheduled?
3. **Come prepared with all relevant materials.**
   Bring several design iterations to discuss and compare.
4. **Presenters should predetermine their questions about their work.**
   What specific concerns or problem areas is the presenter hoping to address?

During Critique

5. **Be sure to tailor suggestions to the presenter's questions.**
   Do the suggestions made help solve a problem?
6. **Record all feedback received.**
   Write down the suggestions recieved or record them to review later.
7. **Don't take suggestions personally.**
   Feedback is about making the work better, not the character or skills of the participant.

After Critique

8. **Discuss what worked and what didn't.**
   What was successful about the critique session? What could be improved for next time?

Good Figures Come From Good Critique Poster

The Figure Design Checklist

Check your final design for these common mistakes.

Check Content

- ☐ **Is the key message of the figure clear?**
  Is the key message the most prominent element in the figure?
- ☐ **Does the information in the visual flow well?**
  Is the order of information easy to understand and intuitive?

Check Basic Elements of Visual Design

- ☐ **Does the proximity of elements relative to one another help or hinder the visual?**
  Does the proximity of elements help clarify the narrative, or unintentionally clutter it?
- ☐ **Is the visual hierarchy of the figure clear?**
  Is it easy to distinguish which elements are more important than others?
- ☐ **Does the visual look unified?**
  Does it look cohesive and consistent? Does anything look like it doesn't belong?
- ☐ **Is there too much or too little color?**
  If there is too much color, the figure may appear complicated and difficult to read. If there is too little, the figure may come across as boring and not attract attention.
- ☐ **Do the colors used have enough contrast?**
  It is difficult to distinguish the separate sets of information due to color?
- ☐ **Are the colors vibrating?**
  Are bold, saturated colors being used together in the figure, causing their edges to vibrate?

Check Overall Design

- ☐ **Is the design cluttered?**
  If a design is looking busy, is there anything that can be excluded or moved to a separate page or graphic?
- ☐ **Check the visual presence of secondary visual elements, such as arrows and boxes.**
  Are these adding anything to the figure or helping it communicate its message? Can they be decreased or removed?
- ☐ **Check the alignment of your visuals and text.**
  Are paragraphs lined up together? Are images and icons evenly spaced?

an independent URL, *researcherstoolkit.design*, as well as the University of Washington Design Help Desk website. This possibility holds merit, as the Design Help Desk receives significant traffic from scientists and researchers, and would be a fitting place to display and distribute the Researcher's Toolkit for Visual Design and Critique.

Adding to the Toolkit

Beyond distribution issues, one of the other concerns with the toolkit was how to improve and update the included materials. While running the workshops gave me insight into the current issues and deficiencies in the visual design resources and skills of scientists, these issues are bound to change and evolve over time. As such, the materials of the toolkit will need to reflect these changes. However, without running further workshops, I am perplexed on how to ensure that I am up to date on current trends and needs and ready to make these necessary corrections. In addition to the potential modification of existing materials, I hope to evolve the toolkit by adding more guidebooks, posters, and other relevant materials on various subjects over time. The problem here is similar, as the addition of new resources would also have to be based on the present visual design needs and issues facing scientists, and would merit significant new research. I'm unsure of how to resolve this specific problem at the moment, but to properly reflect on all of the relevant pain points of the thesis, it is important to discuss and consider these issues.

Next Steps

While my thesis process has concluded, there is still a significant amount of work to be done post-graduation. In the coming months, I plan to complete the following tasks to further refine and forward my work.

Toolkit: While the base materials of the Researcher's Toolkit for Visual Design and Critique are complete, the toolkit itself is still a work in progress. Over time, I intend to add more materials to the toolkit as other needs and interest areas in scientific communication become apparent. Although not ready yet, when finished the toolkit will be available to view, read, and print cost-free at *researcherstoolkit.design*

Academic Publication: The results from the before and after surveys show a shift in the participant's understanding of visual design and critique. After gathering and sorting the survey data, we have found changes in both the participant's self-awareness of their visual and critique skills, as well as in their overall feedback quality. While we ran out of time to work on this within the scope of the current thesis year, throughout the summer of 2021, I will be looking to publish the results of my thesis research alongside my thesis chair, Karen Cheng, as well as our third and fourth authors, Yeechi Chen and Kevin Larson, who helped troubleshoot and guide the research process.

Conclusion

This thesis only scratches the surface of an important, prolific, and relatively unexplored problem area. While my thesis looked to create desirable tools and resources for scientists to self-teach themselves visual design and critique, this is a small solution to the cluster of increasingly wicked problems surrounding scientific communication. However, all problems demand solutions, and the breadth of work in this area is growing to take on these issues that not only impact the scientific community, but the general public as well. My academic journey has been incredibly rewarding thus far and I hope to continue researching this topic moving into the future—it's been a joy to work on such an interdisciplinary project, even as my collaborators and I remain physically separate during the time of COVID-19.

Acknowledgements
I would like to thank my committee members, scientific advisors, the faculty of the Devision of Design, laboratory principal investigators and members, and my cohort for their continued insight, guidance, and support of my thesis work. Thank you for helping make this work possible.

Committee
Karen Cheng
Kristine Matthews

Additional Faculty
Audrey Desjardins
Annabelle Gould

Collaborators
Yeechi Chen
Kevin Larson

Labs + Classes
Averkiou Lab
Pun Lab
Cossairt Lab
Ecoclimate Lab
Engage Group

Staff
Doug Manelski
Flyn O’Brien

References

Alda, A. (2018). If I understood you, would I have this look on my face?: My adventures in the art and science of relating and communicating. New York: Random House.

Burdick, A. (2018, November 19). Some Good News, and a Hard Truth, About Science (Published 2018). The New York Times. https://www.nytimes.com/2018/11/19/science/science-journalism-fake-news.html

Cheng, K., Chen, Y., Larson, K., & Rolandi, M. (2017). Proving the value of visual design in scientific communication. Information Design Journal Information Visualization, 23(1), 80-95. doi:10.1075/idj.23.1.09che

Clarkson, M. D. (2014). Learning how to teach visual communication design skills to scientists and engineers. 2014 IEEE International Professional Communication Conference (IPCC). doi:10.1109/ipcc.2014.7020394

Colusso, L., Do, T., & Hsieh, G. (2018). Behavior Change Design Sprints. Proceedings of the 2018 Designing Interactive Systems Conference. doi:10.1145/3196709.3196739

Dannels, D. P., & Martin, K. N. (2008). Critiquing Critiques. Journal of Business and Technical Communication, 22(2), 135-159. doi:10.1177/1050651907311923

Duarte, N. (2015). Slide:ology: The art and science of creating great presentations. Sebastopol, CA: OReilly Media.

Feliú-Mójer, M. I. (2015, February 24). Effective Communication, Better Science. Scientific American. https://blogs.scientificamerican.com/guest-blog/effective-communication-better-science/

Frankel, F., & DePace, A. H. (2012). Visual strategies: A practical guide to graphics for scientists & engineers. New Haven: Yale University Press.

Ishizaki, S., Rohrbach, S., Tzucker, J., & Clarkson, M. (2008). Teaching visual design without instructors. 2008 IEEE International Professional Communication Conference, 1–9. https://doi.org/10.1109/IPCC.2008.4610211

Kearney, S. (2013). Improving engagement: The use of 'Authentic self- and peer-assessment for learning' to enhance the student learning experience. Assessment & Evaluation in Higher Education, 38(7), 875-891. doi:10.1080/02602938.2012.751963

Kember, D., Mckay, J., Sinclair, K., & Wong, F. K. (2008). A four-category scheme for coding and assessing the level of reflection in written work. Assessment & Evaluation in Higher Education, 33(4), 369-379. doi:10.1080/02602930701293355

Khoury, C. K., Kisel, Y., Kantar, M., Barber, E., Ricciardi, V., Klirs, C., Kucera, L., Mehrabi, Z., Johnson, N., Klabin, S., Valiño, Á., Nowakowski, K., Bartomeus, I., Ramankutty, N., Miller, A., Schipanski, M., Gore, M. A., & Novy, A. (2019). Science–graphic art partnerships to increase research impact. Communications Biology, 2(1), 1–5. https://doi.org/10.1038/s42003-019-0516-1

Marunic, G., & Glazar, V. (2012). Spatial ability through engineering graphics education. International Journal of Technology and Design Education, 23(3), 703-715. doi:10.1007/s10798-012-9211-y

Martin, D. (2012). The cooperative use of material resources and contextual features in graphic design work. Design Studies, 33(6), 589-610. doi:10.1016/j.destud.2012.06.007

O'Mahony, T., Petz, J., Cook, J., Cheng, K., & Rolandi, M. (2019). The Design Help Desk: A collaborative approach to design education for scientists and engineers. PloS One, 14(5), e0212501-. https://doi.org/10.1371/journal.pone.0212501

Otten, J. J., Cheng, K., & Drewnowski, A. (2015). Infographics And Public Policy: Using Data Visualization To Convey Complex Information. Health Affairs, 34(11), 1901-1907. doi:10.1377/hlthaff.2015.0642

Rolandi, M., Cheng, K., & Pérez-Kriz, S. (2011). A Brief Guide to Designing Effective Figures for the Scientific Paper. Advanced Materials, 23(38), 4343-4346. doi:10.1002/adma.201102518

Uluoğlu, B. (2000). Design knowledge communicated in studio critiques. Design Studies, 21(1), 33–58. https://doi.org/10.1016/s0142-694x(99)00002-2.

Weinstein, Sara B, Malanga, Katrina Nyawira, Agwanda, Bernard, Maldonado, Jesús E, & Dearing, M Denise. (2020). The secret social lives of African crested rats, Lophiomys imhausi. Journal of Mammalogy, 101(6), 1680-1691.

Winters, T. (2011). Facilitating Meta-learning in Art and Design Education. International Journal of Art & Design Education, 30(1), 90-101. doi:10.1111/j.1476-8070.2011.01685.

Appendix

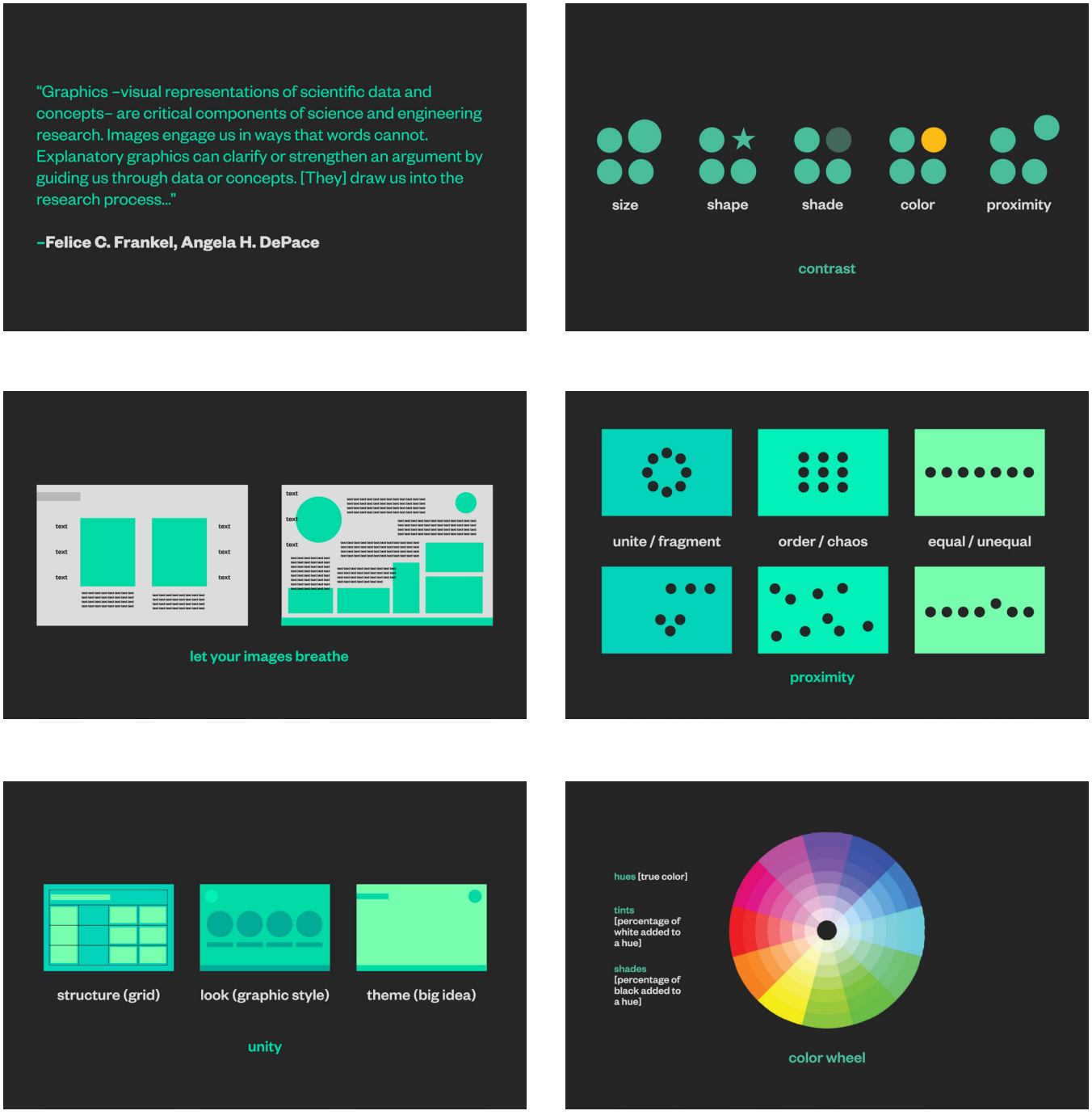


Fig A1
Selected slides from the visual design workshop

Fig A2
Selected slides from the critique workshop

Fig A3
Printable template for The Little Book of Design Critique for Scientists

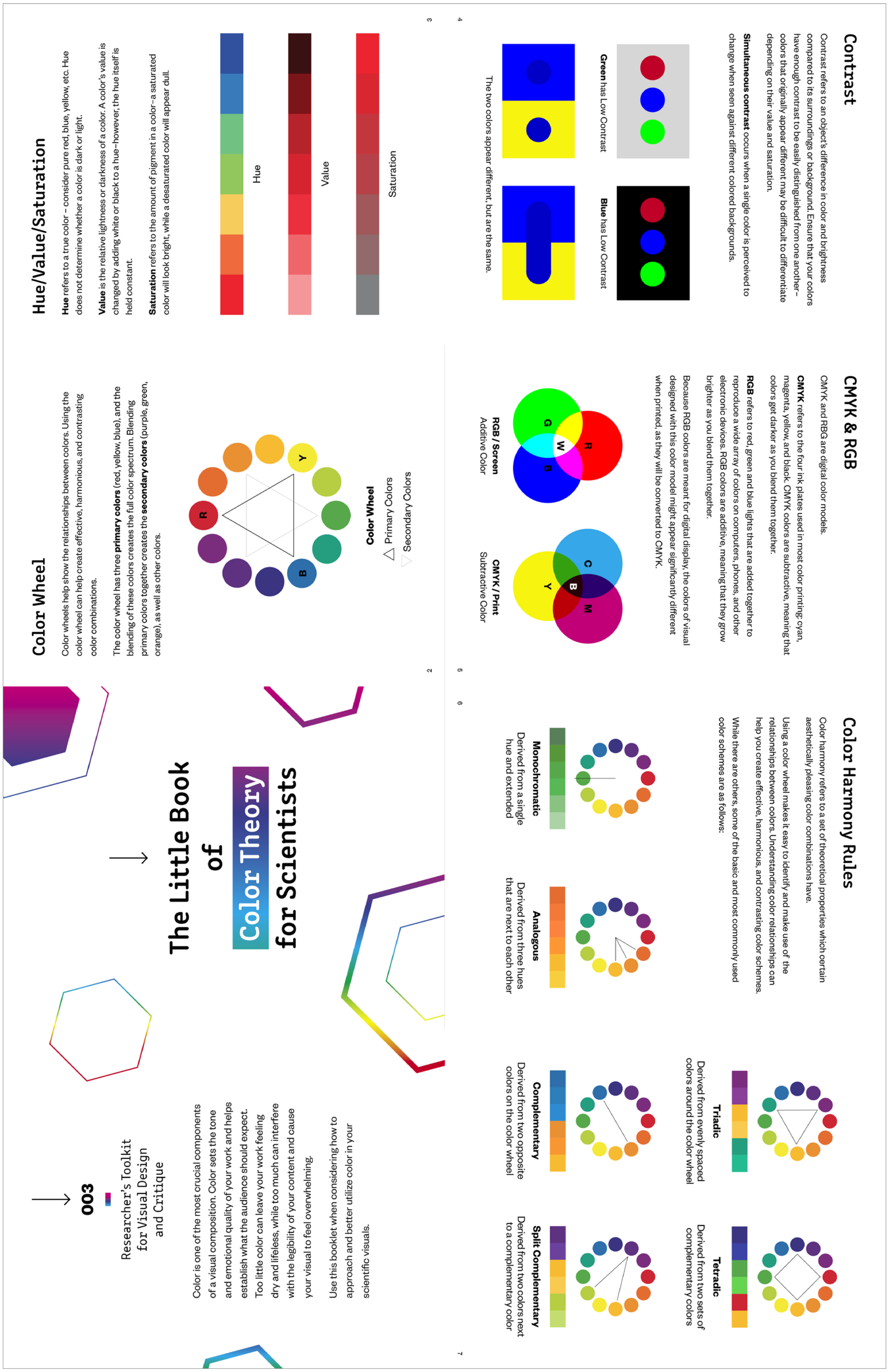
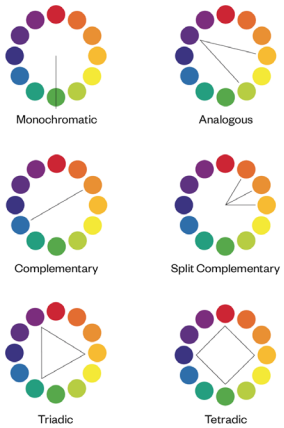


Fig A4
Printable template for The Little Book of Color Theory for Scientists

Fig A5
Side 1 of the printable template for The Little Book of Visual Design Principles for Scientists

Using the color wheel can help you find balanced and contrasting color combinations, in order to differentiate and emphasize your content.

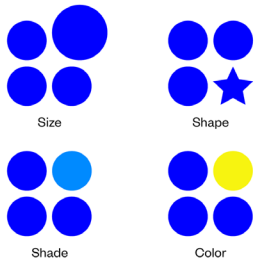


Contrast

a.k.a. using visual cues to emphasize and make clear the informational differences in your work.

Using contrast helps define the relationships between the elements on your page or in your text. The eye groups similar elements together, regardless of their proximity to each other. While contrast methods can be combined to further enhance distinction, they should not be overused in order to avoid viewer confusion.

Some of the ways to create and emphasize contrast in your work are:



002

Researcher's Toolkit for Visual Design and Critique

The Little Book of Visual Design Principles for Scientists

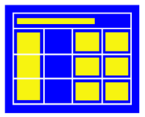
Visual design is an important way to optimize, advance, and make clear the meaning of your work. Bettering your visual design skills will allow your work to more quickly communicate the information you intend it to, avoid unnecessary confusion, as well as look better overall.

Don't know where to start? Consider these principles when creating and refining your next scientific visual.

Unity

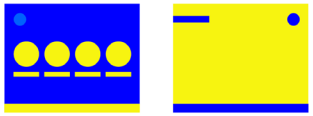
a.k.a. emphasizing overall structural and visual cohesion in your work.

Visual unity can be achieved by standardizing structure (using a grid), look (graphical style), and theme (big idea). A grid is a structure of lines used to organize content that can be used over multiple slides in order to maintain visual consistency.



*Draw rectangles to create regions for placement of elements. Each region is a container for an element. The grid is deleted and saved for later use. This method is particularly helpful for presentations.

Structure (Grid)*



Look (Graphic Style)

Theme (Big Idea)

Hierarchy is also important in text. The size, arrangement, and positioning of different textual elements relative to one another determines their importance.

Larger text has more visual importance than smaller text and is more visually dominant on a page. When arranging text, both text and weight [normal, italic, bold, etc] determine the hierarchical ranking of different textual elements.

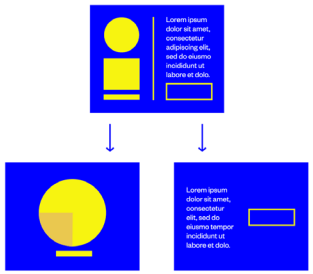
Size & Location Denote Decreasing Importance

Random Arrangements Disrupt Logical Flow

Space

a.k.a. using negative space (the empty areas of a visual) to focus the viewer's attention, show the relationships between elements, and improve overall visual comprehension.

Whitespace is essential, and clutter is a failure of design. If your slide is busy, break it up into several pages when possible.



Break Up Pages With Too Much Information

Continuation

a.k.a. using visual cues to guide a viewer's eye in a certain direction.

According to the Gestalt Law of Continuity, the human eye will follow the smoothest path when viewing lines, even if variables are changed to prevent it from doing so.

Below, note that the eye will follow the straight line into the curved line first, despite the color shift indicating that you should follow the lines designated by color instead.

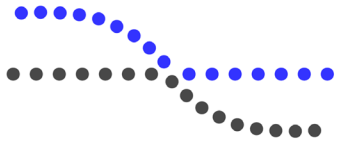


Fig A6
Side 2 of the printable template for The Little Book of Visual Design Principles for Scientists

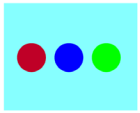
Table of Contents

A booklet of essential visual design principles.

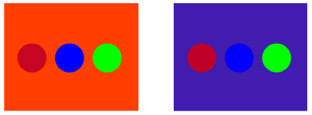
Created by Vassilissa Semouchkina
Want to learn more? Visit *www.sciencetoolkit.design*

The human eye requires contrast in order to distinguish information. In a majority of cases, black and white backgrounds have the best opportunity for contrast because they lack color.

When choosing a color palette, make sure that it contrasts with your background and the other colors you have chosen, and test how it looks on a projector or screen. While colors may seem to have sufficient contrast when first selected, they can still blend in with each other when paired.



Green is Low Contrast

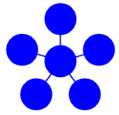


Red is Low Contrast **Blue** is Low Contrast

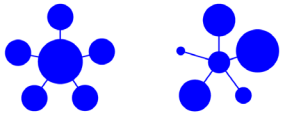
Hierarchy

a.k.a. using visual cues to show the relationships between elements.

Changing the size and proximity of objects shifts a viewer's perception of their relative importance. What story are you trying to tell through the placement of the various elements in your visuals?



Elements Are Equal



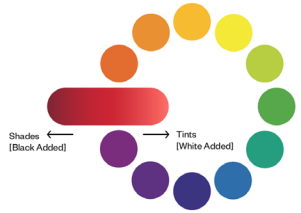
Parent Dominates Child Dominates

Color

a.k.a. what sets the tone and establishes what your audience should expect.

When choosing a color scheme for your work, consider your audience, your industry, and, if applicable, who you are.

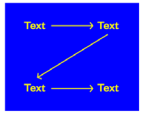
Understanding the color wheel can help you choose a successful palette. The color wheel has 3 primary colors (red, yellow, blue), and the blending of those colors creates the full color wheel.



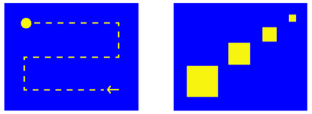
Flow

a.k.a. curating an informational order that determines how a viewer will process you content.

While western reading patterns typically run from left to right and top to bottom (a Z-shape), there are alternative ways to show informational flow.



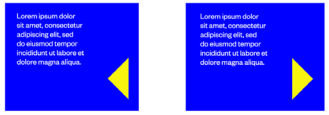
Standard Flow



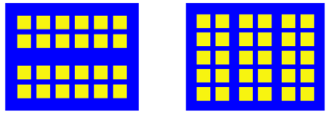
Arrow Flow Perspective Flow

The positioning of different elements in your visual can be used to direct a viewer's gaze–it can help keep a viewer on the page and target them to a different area of content or lead them off of spread entirely.

Elements can be clustered in ways that help direct how a viewer should navigate your visual. Clustering elements around a horizontal gap indicates horizontal flow, while a vertical gap indicates vertical flow.



Element Direction Can Redirect Flow



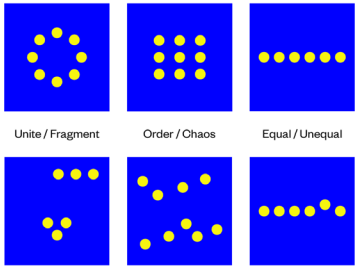
Horizontal Flow Vertical Flow

Proximity

a.k.a. deriving meaning from the location and placement of elements.

Taking care to position the elements in your designs intentionally helps prevent the viewer from making unintended conclusions and helps clarify your narrative.

The proximity of visual elements relative to each other communicates their relationship:

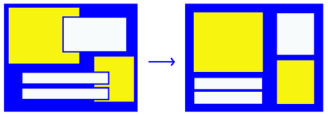


Unite / Fragment Order / Chaos Equal / Unequal

Micro Space

a.k.a. making adjustments to the small spaces between design elements can directly impact content legibility.

Take care to preserve small-scale negative space. Refining the small spaces between visual elements can help improve legibility as well as distinguish and highlight the different sections of your content.



Unrefined Figure Adjusted Figure

Unrefined Text Adjusted Text

ADVANCING VISUAL DESIGN CULTURE IN STEM LAB GROUPS

an exploration of how teaching scientists visual design skills might improve their ability to communicate their work

In essence - scientists are not communicating well. And while resources exist, they are often short-term and inadequate.

Many scientific visualizations, which are supposed to quickly and succinctly communicate scientific work, often look overcomplicated, busy, and overwhelming. While on the surface this issue may not seem overtly sinister, the aftereffects are a lack of peer and public understanding of essential scientific information. There have been various solutions proposed to tackle this issue, ranging from online tools to communication-centered workshops. However, while these solutions may be effective in the short-term, they seldom produce lasting, meaningful change. To tackle these issues, I am considering an intervention at the laboratory level. Most scientists are involved in research laboratories – labs are long-lived, highly collaborative environments that meet frequently and already conduct critique, though seldom on a visual level. Considering my experience in scientific communication and design, I want to fabricate tools and lessons that will help create and sustain a culture of self-education of visual communication in research laboratories.

i want to intervene at the laboratory level

Research laboratories present a unique environment for learning and retaining visual communication design principles. Most scientists are involved in research labs – labs are highly collaborative, structure the researcher's learning, meet frequently, and already sustain critique. It should be noted that the type of critique usually conducted in labs is content-driven, and less about communicative value. However, these aforementioned elements make research laboratories especially conducive to introducing and sustaining visual design principles and critique. Researchers know they need help, and the potential to meet them where they're at holds great promise. To determine what lessons and resources might work best for scientists, I am observing several research laboratories to document how they currently conduct feedback sessions and critique.

i'm currently observing and connecting with several UW research laboratories:

Cossairt Lab: a synthetic inorganic chemistry group focused on building up inorganic nanostructures for targeted applications in light emission, energy harvesting, and catalysis.

Pun Lab: a bioengineering group focused on developing bioinspired materials to advance drug delivery and molecular imaging technologies.

Averkiou Lab: a medical-focused group developing new ultrasound imaging and therapy technology for cancer and heart diseases.

Swann Ecoclimate Lab: an ecoclimate group that explores ecosystem-climate interaction dynamics and addresses fundamental questions about the role of biology in the Earth system.

key research/observation insights

① Scientists want to talk about and improve their visuals, but often lack the skills or abilities to do so. There is little to no provisional training in visual communication in most STEM fields, and while demand is growing, available resources are often not adequate to sustain and retain learned skills.

② Scientists know that design is important, but often relegate improving visuals to a single day or session, close to a submission deadline. There is no continuous visual education or critique sustained throughout lab meetings.

③ In presenting, scientists' slides are almost exclusively visual. However, these visuals are seldom used as aids or assets – instead, they are most often placeholders for text. Many comments during presentation feedback are centered around elaborating on what a certain visual means, insinuating that these figures are adequately designed to help the researcher.

Interested or want to get your lab involved? If so, I'd love to talk more!

Contact me at vsemouch@uw.edu

Fig A7
Image from the Fall 2020 Master of Design Poster Show

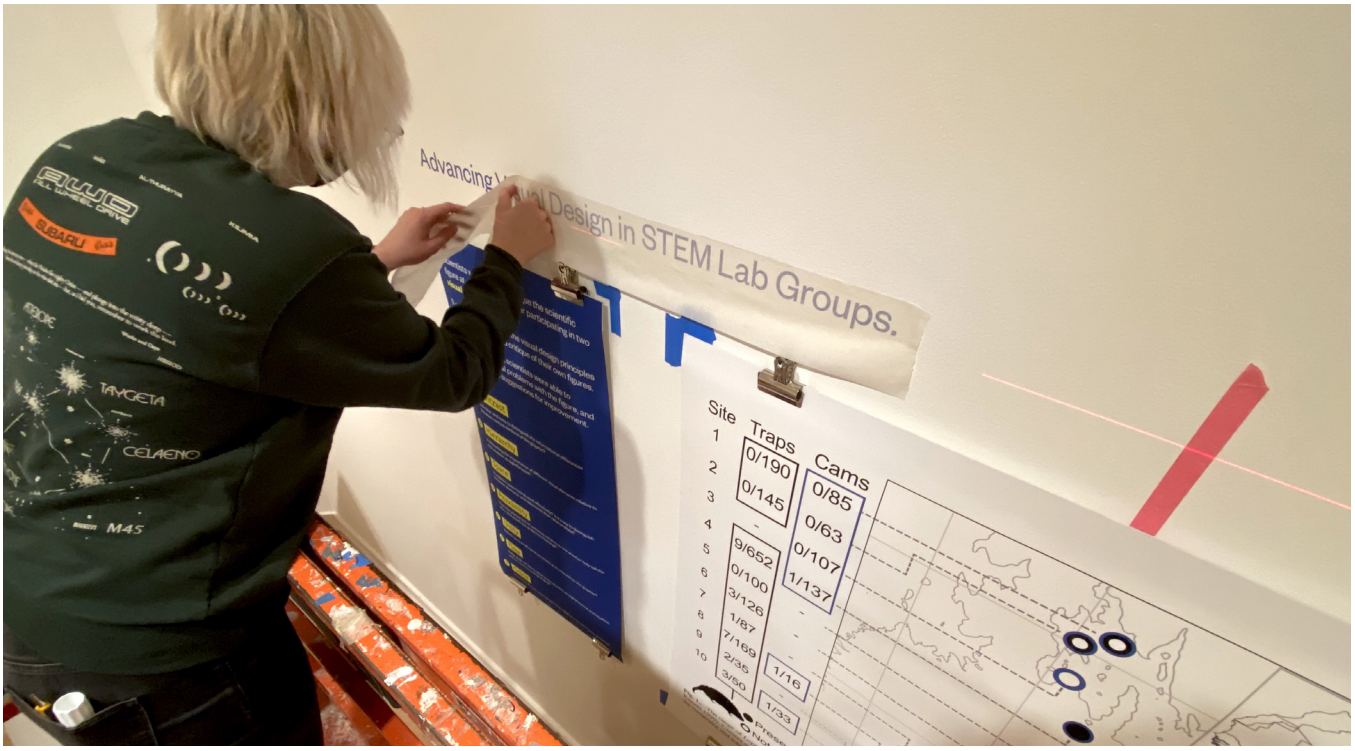


Fig A8 (above)
Installing at the Henry Art Gallery

Fig A9 (right)
Materials from the Researcher's Toolkit for Visual Design and Critique on display at the Henry Art Gallery