

This is an excerpt from Frank Elavsky's dissertation on *Tool-making as an Intervention on the Accessibility of Interactive Data Experiences*, which can be accessed in full at this archival link:

<http://reports-archive.adm.cs.cmu.edu/anon/hcii/CMU-HCII-26-103.pdf>

**This document contains the following sections:**

- Title page
- Acknowledgements
- Chapter 10: Biographical Sketch

**This document does not contain the following chapters:**

- Chapter 1: Introduction
- Chapter 2: Background & Related Work
- Chapter 3: Overview of Contributions
- Chapter 4: *Chartability*: Heuristics as a Tool and Resource
- Chapter 5: *Data Navigator*: Low-level Tooling for Creating Navigable Data Structures
- Chapter 6: *Skeleton*: Visual Authoring of Non-visual Data Experiences
- Chapter 7: *Cross-perception*: Rethinking Input Design Towards Blind Analytical Interaction
- Chapter 8: *Softerware*: Enabling Personalization of Interactive Data Representations for Users with Disabilities
- Chapter 9: Discussion & Future Work



# **Tool-making as an Intervention on the Accessibility of Interactive Data Experiences**

**Frank J. Elavsky**

April 2026

Human-Computer Interaction Institute  
School of Computer Science  
Carnegie Mellon University  
Pittsburgh, PA 15213

## **Thesis Committee:**

Dominik Moritz, Chair, Carnegie Mellon University HCII  
Patrick Carrington, Co-Chair, Carnegie Mellon University HCII  
Ken Holstein, Carnegie Mellon University HCII  
Jennifer Mankoff, External, University of Washington  
Tamara Munzner, External, University of British Columbia

*Submitted in partial fulfillment of the requirements  
for the degree of Doctor of Philosophy.*

Copyright © 2026 **Frank J. Elavsky**

*This research has been partially or fully funded by the  
Human-Computer Interaction Institute, Apple Inc, Highsoft,  
Adobe, and the Chan-Zuckerberg Initiative.*



# Acknowledgments

This acknowledgments section is quite long because I must admit how many people have enabled me to do something like this PhD.

Thanks first and foremost goes to **Shelby**, whose infinite patience and eagerness to hear about my work has given me life through every step of this journey. Thanks next goes to our dog **Pizzelle** and cat **Squid**, who each have given me such profound delight, joy, and comfort through this stage of life. I love our little family.

As far as **material circumstances, media, and technologies** go, I'm thankful for my espresso machine, which made some 14,000 drinks over 11 years before it finally caught fire and died. It made 4-6 drinks every day for Shelby, myself, the pets, neighbors, and guests (Breville should have sponsored me). Leaving behind my barista identity was hard. But as of writing this document, I've now been doing data science longer than I was a barista ( $10 > 9$  yrs). I'm thankful for d3js, especially. This gave me an outlet and a way to fall in love with data, visualization, and code. This may seem strange, but I'm also thankful for r/dataIsBeautiful for giving me an outlet to share my work (and make it onto the front page of Reddit once or twice). And of course, (I can hear Sanika and Lisa laughing about this as I write it), but I'm thankful for Twitter, RIP (especially between 2017 and April 13th, 2022 before it was bought and then slowly died). Twitter probably landed me this PhD, but it certainly helped me find my grown-up identity and community of like-minded folks. I'm thankful for the Lord of the Rings, Frieren, One Piece, Disco Elysium, Fallout, and Elden Ring (my comfort media). I'm also, despite its shortcomings, thankful for our home. I will miss it when we move from here. I've learned that moisture is the greatest enemy of a comfortable home. And (again, can hear friends laughing at this), but I'm thankful for Uniqlo's t-shirts, which have been an immense staple for years. I've managed to get significant mileage out of every one of these. Thanks to our cast iron skillet, dutch oven, couch, bidet, grill, bed, good set of knives, and gaming computers. Money *can* buy (a little) happiness.

Next, I want to give thanks to the **DatavizA11y community members** and my foundational family in accessibility and visualization: Larene Le Gassick (just a collaborator at the time but now someone whose friendship is dear to me), Liz Hare, Silvia Canelón, Léonie Watson, Emily Kund, Sarah Fossheim, Ted Gies, Melanie Mazanec, Amanda Makulec, Amy Cesal, Øystein Moseng, Chris DeMartini, Ryan Shugart, Jennifer Zhang, Amber Thomas, and all our friends and members not listed. This group has given me immense support over the years. And special thanks to Doug Schepers of Fizz Studio for sponsoring Chartability and for your gracious encouragement, support, and feedback over the years. It has been strange to meet such a kindred spirit at such a small intersection. I'm immensely thankful for your friendship.

I also want to thank all of the **industry folks** who have been encouraging and supportive of

me, many of you have let me know you're using my work or it has helped you in some way (which has helped me carry on through all of this): Alan Wilson (such a wonderful friend and encouraging collaborator), Tony Fast (thank you so much for your honesty, passion, and truly genius experiments), Amanda Makulec (for always connecting me, giving me opportunities, and encouraging me), Jasmine Mithani, Lindsay Silver, Anna Cook, Sara Elizabeth Temby, Tobias Kauer, Saara Kamppari-Miller, Elle Waters, James Nurthen, James Craig, MJ Jawili, Ben Jones, Alli Torban, Johny Cassidy, Travis White, Kai Chang, Kent Eisenhuth, Fanni Melles, Jim Lane, Julia Wolfe, Taha Hassan, Jen Strickland, Patrick Garvin, Gabrielle Merite, Maxene Graze, Vini-cius Sueiro, Sharron Rush (and all the Knowbility folks), Michael Jordan (no, not that one), Ian Smith, Nicolas Kruchten, Jim Webber, Sam Aaron, and everyone else at Apple, Google, Visa, Adobe, Highsoft, T-Mobile, Jupyter, Quansight, Celonis, Voilà, Data Literacy, Finn.no, Green-Info, Feedzai, Canva, Observable, Figures and Figures, and many others not already listed. You know who you are. Thank you so much for your support and for not only using my work, but for letting me know and giving me feedback too. Special shoutout to Eric Bailey for being such a great supporter of my work and fantastic conversation partner.

Immense thanks to the folks who have used Chartability in **governmental and policy** contexts. Chartability was intended to be a gift to everyone, so socially contributing to public good was the ideal. Thanks to the immortal legend (and very early hero of mine) Moritz Stefaner who used Chartability to help the World Health Organization develop their Data Design Language. It is hugely flattering for someone I look up to as a pillar to leverage my work. Big thanks to Maarten Lambrechts for letting me know how central Chartability was to the European Commission's Data Visualization Guide, especially their Accessibility section. Thanks to Francis Gagnon (not only for being such a great steward of our field but also for your support) as well as for getting the Quebec government to use Chartability for their design system. Special shoutout (again) to Melanie Mazanec for getting Chartability connected to the State of New Jersey's Open Data Center and State of California's Office of Innovation. Thanks to Emily Vontsolos, Blake Valenta, and Lauren Jong for our wonderful collaboration while y'all were with the City of San Francisco. And thanks to the anonymous folks at the Congressional Budget Office, NIH Common Fund (RIP), Office of Science and Technology Policy, 18f (RIP), USGS, USAID (RIP), and United States Web Design System (RIP?).

Thanks to all the **academics and researchers** who have supported me over the years. I first want to thank Alberto Cairo, who is also a pillar to me (and someone who, during my early years, I regarded as the "coolest person in data visualization"). I cannot believe we've become friends and you've been so supportive of my work (and tabletop rpg!). Thanks to Vetrica Byrd, whose vision led to the REU I participated in and ultimately first exposed me to research in data visualization. Thanks to Steve Franconeri for generously letting me, an absolute gremlin, sit in on your lab meetings back when I was at Northwestern. Thanks to Gabriel Hankins for your mentorship. Thanks to Aimen Gaba, Venkatesh Potluri, Jon Froehlich, Jeff Heer, Anhong Guo, Kim Marriott, Matt Kay, Dan Fan, Alexa Siu, Niklas Elmqvist, Danielle Albers Szafir, Derya Akbaba (a truly splendid human!), Miriah Meyer, Evan Peck, Nam Wook Kim, Yea-Seul Kim, John Thompson, Leona Holloway, Matthew Butler, Jim Smiley, Bongshin Lee, Ria Khan, Sandra Bae, Arran Wang, Fumeng Yang, Abhraneel Sarma, JooYoung Seo, Rachel Wood, Shira Abramovich, Meredith Broussard, Liz Jackson, Rua Williams, Garreth Tigwell, Jasmine Lu, Rahaf Alharbi, Leya Breanna (Bre!) Baltaxe-Admony, Kathryn E. Ringland, Anastasia Schaad-

hardt, Lawrence Weru, Ather Sharif, Andreas Stefik, Sile o’Modhrain, Taliesin Smith, Volker Sorge, Rupesh Vyas, Jonatan Hildén, Joel Chan, Laura Garrison, Krisha Mehta, Emma McDonnell, Jesse Martinez, David Widder, Steve Haroz, Alex Kale, Jaylin Herskovitz, Josh Pollock, Elsie Lee-Robbins, Cindy Xiong Bearfield, Bill Limpisathian, Vanessa Knoppke-Wetzel, Fatima Koli, Matt Brehmer, Nur Yildirim, Fred Hohman, Donghao Ren, Mary Beth Kery, James Craig, Leah Findlater, Jackie Milhans, Aaron Geller, Shane Larson, Amy Ko, Torsten Möller, Mols Sauter, Stephanie Valencia Valencia, Péter Gyarmati, Attila Batorfy, Katta Spiel, Lauren Klein, Catherine D’Ignazio, and Richard Ladner (who, in a roundabout way made me avoid a “pure” computer science PhD and pursue one in HCI instead; life-saving, really).

I want to give special thanks to Pramod Chundury and Naimul Hoque for assembling Keke Wu, Laura South, Brianna Wimer, Stacey Hsueh, and me into our little workshop community. I consider all of you like my **academic siblings** at this little intersection of visualization and accessibility research. I’m so thankful we are part of a generation of researchers together.

I am hugely thankful for the creative and **inspiring practitioners** in the data visualization community who all contributed to me falling in love with our shared practice over the years: Federica Fragapane (whose work, most of all, I love dearly - we don’t deserve you!), Shirley Wu, Georgia Lupi, Valentina D’Efilippo, Nadiéh Brehmer, Tiziana Alocci, Stefanie Posavec, Sonja Kuipers, Kim Albrecht, Matt Daniels, Jan Diehm, Jennifer Christiansen, Nicholas Rogueux, and Mike Bostock to name a few.

Thanks to my **CMU colleagues** who have either been supportive of my work or inspired me to be better in some way: Lea Albaugh, Scott Hudson, John Stamper, JZ, Sarah Fox, Hiro Shirado, Haiyi Zhu, Jeffrey Bigham, Andy Begel, Anna Kawakami, Pranav Khadpe, Anna Fang, Christine Mendoza, Faria Huq, Luke Guerdan, Frederic Gmeiner, Jessie Mindel, Kimi Wenzel, Adinawa Adjagbodjou, Sireesh Gururaja, and Peya Mowar. Immense thanks to Catarina Gonçalves Fidalgo for being so encouraging and kind to me about my comm talk (before we discovered I was one of only two who had failed!). That comment really carried me.

Thanks to my **advisors** Dominik and Patrick and to my **committee members**, Jen Mankoff, Tamara Munzner, and Ken Holstein. Dominik, your advice that a PhD “should feel a bit selfish if you’re doing it right” (I’m paraphrasing) was perfect. Thanks for letting me pretty much do whatever I wanted and opening doors for me, while also keeping me on track. Jen, your work has shifted and re-shifted my thinking many times and I feel like I got away with some kind of trick having you on my committee. You’re also just a wonderful person and set an example as the sort of advisor I think I’d like to be someday. Tamara, I’ve told you this already but I want it on this record (for official reasons), but of all the credit for why I got into data visualization, the most goes to you and your book, which I picked up hot off the press in 2015. That really started everything. And Ken, I don’t think there is a professor at CMU who has more consistently put up with my nonsense than you. I love your curiosity and willingness to let me really wax philosophical in class discussions. I hope to grow up to be a teacher like you someday.

Thanks to *the holy trinity* from the MIT Visualization Group (and Arvind Satyanarayan too, of course): Alan Lundgard, Crystal Lee, and Jonathan Zong. All three of you really inspired me to get into visualization and accessibility research but also helped me feel like I was welcome in this space too. Crystal, you have been so generous and supportive over the years, thank you for that. And Jonathan, I swear I just think you’re the coolest person ever. I’ve enjoyed every single chat we’ve had over the years and cannot thank you enough for really helping me to find

my voice and vision time and time again. I have no idea how Arvind managed to assemble a lab with all of your skill and talent in a single place, but you all really did incredible things together.

Thanks to all of my **collaborators and co-authors** on the projects, papers, and articles we have had together: Venkat Sivaraman, Yunzhi Li, Joon Jang, Cindy Xiong-Bearfield, Lucas Nadolskis, Cindy Bennett, Øystein Moseng, Marita Vindedal, Ted Gies, Jess Hammer, Erik Harpstead, Noor Hammad, Jessie Chen, Seyoung Lee, Lilian de Greef (special thanks for inviting us to be part of your wonderful D&D campaign, too), Tania Allard, Pavithra Eswaramoorthy, Gabriel Fouasnon, Mateusz Paprocki, Emily Barone, Mark Lee (and the whole community at LAMP that you've let me continue to hang with), and Caroline Rose. Some of you had to put up with me more than others. I'm immensely thankful for all of you being so patient.

Thanks to the **financial enablers** who opened doors for collaborations (Dominik aside, of course, since he has been the main patron of my work these past 5 years): Jørgen Tistel for being so kind and generous with our Highsoft collaboration (and also being a wonderful host during our time there in Vik), Alan Wilson (for all of your legwork over at Adobe, both building bridges slowly and quickly), Tania Allard (for making our stupendous collaboration with Bokeh possible), Jonathan Schwabish (for putting that report together for the Urban Institute and basically letting me invite a bunch of my friends to get paid to be co-authors), Alberto Cairo, Julia Wolfe, Caroline Rose, and other folks who I can't name (but you know who you are). I would love to work with all of you again, if our paths could align. Thanks for making things happen.

Thanks to my **labmates** (at DIG and AXLE) not mentioned elsewhere: Adam, Will, Katelyn, Alex, Franklin, Ezra, Arpit, Atieh, Catalina, Esther, Vijay, Pranav, Scott, James, Daesung, Seokweon, Donny, Lukas, and Eric. You're all brilliant people. I cannot believe I was able to occupy the same space as all of you. You're very accomplished and will surely go on to do great things. Thanks for your feedback, encouragement, engagement, ideas, and laughs over the years. Thanks also to my favorite **undergrad mentees and friends** for putting up with me: Iman, Chieri, Jillian, Areen, Julia, Ellie, and Ihita. I can't wait to see your adventures unfold.

Thanks, to the **foundational people** in my life who pulled (or pushed) me out of terrible places or were otherwise there for me when I really needed it. Thanks, mom. Thanks to Craig and Beth, for being like parents to me in my younger years and inspiration to Shelby and me in our more-grown-up years. I wouldn't be the person I am today without you two. Thanks to David Montgomery for your insistence in my value as a person. Thanks to the Powells for being a home away from home many times while I grew up. There were countless nights I needed a bed and food and you didn't think twice to take me in. Thanks to Jeff D'Angelo for firing me from your pizza shop and then to Gus Gosanko and Liz Jenkins for telling me I should apply to college. Thanks to Liz for introducing me to Jeff Mallinson and to Mallinson for giving me that huge scholarship (I still have no idea why you did it). The Dean's Circle changed my entire life. Thanks to Stacie too, of course. We love both of you very much. You two showed me how cool it is to be a "sexy murder poet" style of philosopher. Thanks to Annemarie Russell for exposing me to queer and feminist thought and for putting up with my nonsense in the Dean's Circle. Thanks to Erik Samuelson for not only exposing me to community organizing but giving me multiple funded opportunities to learn and put organizing into action. Those experiences radicalized me and fully established my sense of justice and political identity to this day, beyond any doubt. Thanks to Michael DeLashmutt for your mentorship and being the one who enabled me to get into computer stuff, which ultimately sent me on this trajectory and led me to this PhD. I am so

thankful for your wit, mentorship, and perspective.

Thanks to the **teachers** in my life, Mr. Donaldson (for being the first person, perhaps in my life, to insist that I was worth something), Mr. Buchanan (teaching me that living the dream is possible), Mrs. Rickson (helping me realize the importance of my influence over others), Mr. Dellutri (for teaching me to love art, which has carried me through life), Mrs. Strohschein (for loving my fiction - someday I'll send you a copy to sign like you asked), and Mr. Burnett (for giving me a love of theater and performing, and also the first class that Shelby and I shared together). Thanks to Mario Guimaraes, Bruce Grigsby, Betsi Little, Yeheil Curry, Patrick Reyes, Callid Keefe-Perry, Marty Folsom, Liz Colver, Andrea Ide, Andrea Paul, Ryan Torma, Tucker Fitzgerald, and Dave Ellingson for exposing me to entirely new ways to think about the world and understand myself in it.

This final section is the hardest to write briefly, but I specifically want to thank **my friends** who have, in some way shape or form, made my survival during this PhD possible. First: I don't want people to think that if you're not here, you're *not* my friend! This section is more reserved for folks who aren't part of a previous category. Most folks already listed are friends. So to our friends from the bay, thank you: Jaime and David (I miss you both so much), Kevin, Tica (I'm so proud of you!), Layla, Sandy+Chris+Lilly, Kat+Phil+Phin (hoo boy does Pizzelle miss Phin and Lilly!). Thanks to our guildmates (I am so proud to have set world records with some of you and gone on wonderful adventures as well): Matt, Kate, Karen, Resa, Ham, Ang, Grun, Cel, Leru, Tabby, Bael, Eliabell, and Kata. Thanks, as always, to my best man Robert. I am so proud of your tabletop RPG and how far it has come. Thanks to Erickson, for your spirit and energy. Thanks to Oscar and Chancey Fleet, Varsha, Jenni, Andy, David S, Katie M, Rosemary, and my cousins Lea, Leah, Sarah, and Jeannie for rooting me on. Thanks to my friends from our days in Everett who have stayed in touch over all these years: Joe and Tess, Tucker and Hannah, the Kinsmans, Matt W, Sammy "White Ice," Stephen, Mallayana, Sarah, Rachael, Dwyer, Shannon, Judith, Alisha, Bree, Jeff F, Michelle, Tuugi, Doug, Connie, Drew, Josef, Curry, Derek, Esca, Amy, Colter, Libi, Dana, Misael, and all of you little gems in the fantasy league (Pete, James, Phil, Cluffy, and Zach). Thanks to Damian and Larene (overseas besties!). Thanks to Kirsty and Simon, Katja, and Jim from the Council of Coffee. Thanks to Charles, Roy, Anouk, Kat, Aaron, Brunty, and Sarah. I am also immensely thankful for folks who have been good friends during our time here in Pittsburgh: Cella and Tucker (I love you two so, so much), Grant Stoner (the legend!!), Franky, Naomie, Alicia, Jordan, Noor, Erica, Lisa, Hwei-Shin, Joon, Sanika, Lukas, and Ruben and Em. Thanks to our neighbors for helping us time and time again and for your friendship: the Dugans, Manchowskis, and Honaths (we will miss Atlanta Drive and all of you).

I want to end with a few **un-acknowledgements** too: No thanks to my (literal) disabled ass, which made all of this harder. The struggle did not make me stronger or give me an inspiring story. No thanks to gen AI and LLMs. Even if these models were ethical, I'd still be a luddite. I write because I have things I want to say and thoughts I want to feel form (in the same way I dance because I, selfishly, want to feel my own body). Why give the gift of my own living to a machine? GenAI is to self-actualization what frozen microwave meals are to culinary arts.

And despite the noble-sounding reasons for my research, ultimately I did it for myself because I wanted an adventure. And I'm so glad I have proved my haters wrong in the end: I had a wonderful time and it was worth it. I have been so supported, challenged, loved, and cared for in my life by so many people. This compels me to live well. I won't waste your gifts. Thank you.



# Chapter 10

## Biographical Sketch

Frank Elavsky was born in Seattle, Washington and grew up in Anacortes, to the north on Fidalgo Island. He was raised in poverty by a single mother on SSDI who lives with multiple disabilities; his father is multiply disabled and homeless. Frank himself has chronic pain and disability, as well as living with diagnosed and self-diagnosed neurodivergence. In his early years in school, he had alternative classes and behavioral interventions. In middle school, he began working on a fantasy world and tabletop game called *Braven*. He was not a notable student in high school and did not receive honors. He was in and out of surgeries and the emergency room, missing over 180 days of school combined across his junior and senior years. At the time, he loved traditional art and was accepted into Cornish School of the Arts in Seattle. He could not afford to attend.

Upon turning 18 but before graduating high school, he was kicked out of his house by his mother, who had just sold his car for opiates. After several surgeries by his 19th birthday, his health significantly improved. He then worked several odd jobs (furniture mover, barista, carpenter, painter) until getting fired from a pizza shop at age 21. He crashed out and applied to a nearby liberal arts college, Trinity Lutheran, in Everett, WA. He was awarded a substantial scholarship. 5 years later he graduated Magna Cum Laude with two degrees, a B.S. in Computer Information Systems, and a B.A. in Theology and Philosophy.

While attending, he was committed to serving his peers as Student Body President and also did substantial work in his spare time as a community organizer, fighting for student, housing, and carceral justice at Trinity and in the Everett area. He married Shelby while attending Trinity, who was a close friend from home in Anacortes. Trinity closed as a college and became a foundation the year he graduated (2016), because students, staff, and faculty organized against corruption. (On rare occasions, Frank has been known to spill his insider-exclusive tea on all of this over drinks, with close friends.)

He then worked in industry, specifically in data visualization. His visualization work won several awards, even appearing (uncredited) in the 2017 Nobel Lecture on Physics by Barry Barish (see Fig 9 in [? ]). Despite this, he was always terrified with impostor syndrome.

At 31, he left a well-paying, comfortable career with excellent health insurance and started his PhD at Carnegie Mellon University. During his PhD, his work has been recognized for its significant societal contributions, shaping data visualization and accessibility work in: 15+ government and policy orgs internationally (World Health Organization, European Commission), 80+ businesses and corporations (including 3 of the Fortune 5), 20+ news and journalism groups (BBC, NYT), 50+ community organizations and non-profits (Special Olympics, Data Viz Society), and 24+ higher-ed classrooms.

Frank credits his success and happiness to many second chances, unearned opportunities, and genuine kindness given to him in his life. He did not succeed “despite adversity” (as is a common framing with disability and poverty) but simply because many people supported him in his life and still do. He continues to play and work on his “paracosm” [? ? ] *Braven* and it is his longest-running, sustained passion in life.