Workshop as an Educational Intervention: Improving the Knowledge and Understanding of Data Visualization Accessibility for Visualization Creators

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ABSTRACT

Enhancing visualization creators' knowledge and understanding of the accessibility of data visualizations remains a critical step toward reducing the digital divide screen-reader users experience. Recently, Sharif *et al.* shed light on the challenges visualization creators face with making data visualizations accessible to screen-reader users, identifying four technological interventions and one educational intervention (*i.e.,* workshops) to minimize these challenges. Although they implemented the technological intervention and provided guidelines to conduct an effective workshop, they did not implement a workshop for creators. I extend their work by conducting a workshop for visualization creators based on their findings. My results show that the workshop improved the creators' accessibility knowledge by 39%, prioritization of implementing accessibility by 15%, perceived importance of accessibility by 4%, challenges with making visualizations accessible by 16%, and desired frequency of conducting studies with screen-reader users by 157%.

CCS CONCEPTS

• **Human-centered computing** → **Empirical studies in visualization**; **Empirical studies in accessibility**; • **Social and professional topics** → **People with disabilities**.

KEYWORDS

workshop, data visualization, accessibility, screen reader, creators

ACM Reference Format:
Ather Sharif. 2024. Workshop as an Educational Intervention: Improving the Knowledge and Understanding of Data Visualization Accessibility for Visualization Creators. In *Woodstock '24: ACM Symposium on Neural Gaze Detection, June 03–05, 2024, Woodstock, NY*. ACM, New York, NY, USA, 6 pages. https://doi.org/XXXXXXX.XXXXXXX

Conference acronym 'XX, June 03–05, 2024, Woodstock, NY

ACM ISBN 978-1-4503-XXXX-X/18/06
https://doi.org/XXXXXXX.XXXXXXX

1 INTRODUCTION

Making data visualizations accessible to screen-reader users[1] has gained significant momentum in the past few years [5, 9, 11–14, 20]. Several solutions exist that improve data access for screen-reader users from online data visualizations, including multi-modal [4, 24, 25, 27], summarization [10, 21], and sonification [1, 6, 17, 23, 26] solutions. While these solutions target the critical issue of *data consumption* by screen-reader users, they do not address the visualization creators' need to enhance the knowledge and understanding of data visualization accessibility. Minimizing the challenges they experience can assist in improving the state of accessibility of data visualizations.

Joyner *et al.* [8] explored the creators' challenges with accessibility. Sharif *et al.* [22] extended their work by further shedding light on the obstacles and identifying four technological and one educational intervention to reduce these challenges. They reported that workshops can assist creators as an educational intervention and identified features that make these workshops more effective. However, in their work, they only implemented the technological interventions and deferred the workshops to future work. Therefore, in this exploration, I followed the guidelines by Sharif *et al.* to organize a workshop on data visualization accessibility for creators.

Specifically, in a partnership with the Open Scholarship Commons at the University of Washington, I built and conducted a workshop for 14 visualization creators on making data visualizations accessible to screen-reader users. I administered a pre- and post-workshop survey to assess the workshop's impact using a mixed-methods approach. Particularly, I investigated the change in creators' (1) accessibility knowledge, (2) prioritization of implementing accessibility, (3) perceived importance of accessibility, (4) challenges with making visualizations accessible, and (5) frequency of conducting studies with screen-reader users. My findings show a promising improvement in each of the above, reporting a 39%, 15%, 4%, 16%, and 157% enhancement, respectively. Additionally, the participants expressed positive learning experiences from the workshop, stating that their "expectations were met and exceeded."

This work's contribution includes the implementation of a workshop on data visualization accessibility for visualization creators. Further, I provide the empirical assessment of the workshop's impact. Additionally, I offer the recording of the workshop available at https://www.youtube.com/watch?v=D2qI8ZLzPug.

[1] Screen-reader users are users who utilize a screen reader (e.g., JAWS [18]) to read the contents of their computer screen; they may use a screen reader for permanent or temporary purposes. They might have complete or partial blindness, low vision, learning disabilities (such as Alexia), motion sensitivity, or vestibular hypersensitivity.

Table 1: Features identified by Sharif *et al.* [22] to implement an effective workshop on data visualization accessibility and my actions in implementing these features in this workshop.

Features	Actions
Synchronous presentation	The workshop was conducted synchronously in real time.
In-person attendance	The workshop had primarily in-person attendance, with Zoom available for remote attendees.
Screen- and non-screen-reader users as co-instructors	The workshop was co-instructed by a screen- and a non-screen-reader user. The screen-reader instructor participated virtually.
Demonstration of the experiences of screen-reader users	The workshop showed a recorded demonstration of a screen-reader user interacting with an online data visualization. Further, an interview with a screen-reader user was shown in which the screen-reader user provided a detailed account of their experiences.
Making materials available post-workshop	The workshop was recorded and uploaded on YouTube for public access at https://www.youtube.com/watch?v=D2qI8ZLzPug. Additionally, QR codes were added to slides for easy access to audio/video content.

2 WORKSHOP FOR CREATORS

I organized a workshop for creators on making data visualizations accessible. I discuss my methodology and findings below.

2.1 Preparation

I designed the workshop incorporating the effectiveness features identified by Sharif *et al.* [22] (Table 1). The preparation for the workshop took 3 months and included determining objectives, building a lesson plan, and a dress rehearsal. Additionally, I sought iterative advice and feedback from mentors at the University of Washington with extensive expertise in conducting workshops to formalize the objectives and lesson plan, and the structure to make the workshop more engaging and collaborative.

2.2 Participants

I advertised the workshop through collaboration with the University of Washington Libraries and the eScience Institute at the University of Washington. The participants were 14 visualization creators (Appendix A), all affiliated with the University of Washington in varying capacities (*e.g.,* students, teachers, and staff). The total number of attendees was limited to a small classroom size to foster collaborative learning. Twelve identified their gender as women and two as men. Their average age was 37.1 years (SD=10.1). Three had attained or were pursuing a doctoral degree, six a master's degree, and the remaining five a bachelor's degree. All participants had had minimal experience with accessible data visualizations at the time of the workshop. Participants attended the workshop voluntarily and did not receive financial compensation.

2.3 Procedure

The workshop took place in an in-person setting, lasting an hour. The workshop comprised three sections: (1) *The Problem*, (2) *Common Practices*, and (3) *Future Avenues*. Before the beginning of the workshop, the participants filled out the pre-workshop questionnaire that collected their knowledge, prioritization, and perceived importance of accessibility ratings using a Likert scale ranging from 1–7 ("1" being lowest and "7" being highest). Using the same scale, participants also specified their rating for challenges they face with data visualization accessibility and their desired frequency of conducting studies with screen-reader users. To avoid the Hawthorne effect [7, 19], participants were not made aware that they were being studied until the end of the workshop. They were also given the choice of opting out from the study at the end of the workshop.

In the first section, my goal was to assist participants in building an in-depth understanding of the problem of data visualization accessibility. Therefore, I illustrated the inaccessibility of data visualizations through a recorded interaction of a screen-reader user with an online data visualization depicting COVID-19 cases per U.S. state. Next, I played a 10-minute-long pre-recorded interview with a screen-reader user, who shared his experiences with digital accessibility in general and with data visualizations in particular, as suggested by Sharif *et al.*.

Next, I demonstrated four common modalities used to make data visualizations accessible to screen-reader users: (1) alternative text ("alt-text"), (2) sonification, (3) 3-D printing, and (4) data tables. Following the demonstration, the attendees partook in an activity to discuss these modalities and their experiences with these modalities with another attendee, subsequently sharing the summary of their discussion with the rest of the attendees. After the activity, I presented the advantages and shortcomings of each modality, building on the discussion from the activity.

Finally, in the third section, I discussed multi-modality and other resources beyond the four modalities. Specifically, I demonstrated the functionalities and integration of various multi-modal solutions, including `VoxLens` [24], into existing visualizations to make these data visualizations accessible. Lastly, I provided attendees with three "homework" topics to ponder with their colleagues and community members in making data visualizations accessible to screen-reader users: (1) equity, (2) user agency, and (3) non-keyboard-based interactions. I plan to organize workshops on these topics separately in the future to appropriately convey the nuances of each of these

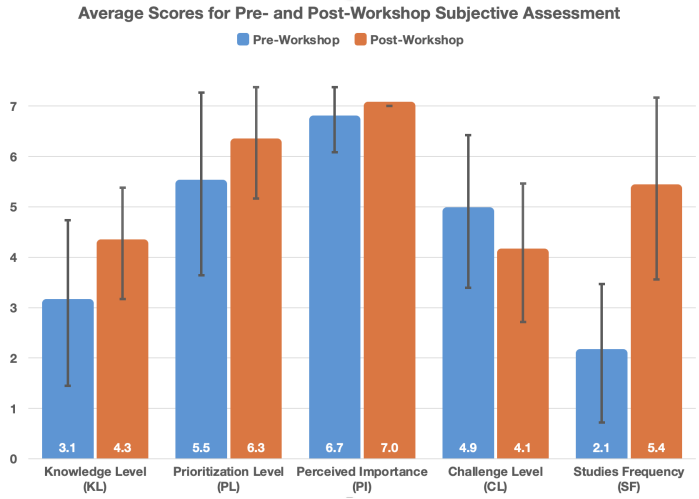

Figure 1: Visualization showing the Likert scale scores (with "1" being the lowest and "7" being the highest) for the pre- and post-workshop subjective assessments. Higher scores are better. Error bars represent mean ±1 standard deviation.

topics and assess their learnings over time. At the end of the workshop, participants filled out the same questionnaire as the one at the beginning of the study, with an additional open-ended field for comments and feedback.

Table 2: Statistical results from the mixed ordinal logistic regression analysis from N=11 visualization creators with *Questionnaire Time* (*QT*) as the independent variable ("pre-workshop" *vs.* "post-workshop"). "DV" means dependent variable. Results with $p < .05$ are statistically significant.

DV	χ^2	p
Knowledge Level (*KL*)	7.53	< .05
Prioritization Level (*PL*)	3.44	.063
Perceived Importance (*PI*)	9.12	< .05
Challenge Level (*CL*)	3.51	.061
Studies Frequency (*SF*)	15.09	< .001

2.4 Design & Analysis

I investigated the differences in participants' pre- and post-workshop subjective responses. The independent variable was *Questionnaire Time* (*QT*; within-Ss.), having two levels ("pre-workshop," "post-workshop"). The dependent variables were *Knowledge Level* (*KL*), *Priority Level* (*PL*), *Perceived Importance* (*PI*), *Challenge Level* (*CL*), and *Studies Frequency* (*SF*); all dependent variables were ordinal (1 to 7 on a Likert scale; "1" being the lowest and "7" being the highest). I used mixed ordinal logistic regression [15, 16], a standard statistical analysis for ordinal data without multi-collinearity, to analyze the effect of *QT* on each of these variables. Three participants did not finish the post-workshop questionnaire and were therefore not included in the analysis. Additionally, I used thematic analysis to analyze participants' open-ended feedback and comments from the post-workshop questionnaire.

2.5 Results

I analyzed the results using quantitative and qualitative analysis. I present them in turn below.

2.5.1 Quantitative Results. *Questionnaire Time* (*QT*) had a significant effect on *Knowledge Level* (*KL*), *Perceived Importance* (*PI*), and *Studies Frequency* (*SF*). *QT* had a marginal effect on *Priority Level* (*PL*) ($p \approx .063$) and *Challenge Level* (*CL*) ($p \approx .061$). These findings indicate significant differences between the participants' subjective responses pre- and post-workshop (Table 2). Specifically, post-workshop scores show an improvement in participants' knowledge, prioritization, and perceived importance of accessibility by 39%, 15%, and 4%, respectively. Furthermore, participants decreased their ratings of the challenges they face with accessibility by 16% and increased their desire to conduct studies with screen-reader users by 157% (Figure 1). It is worth noting that the smaller percentage increase for perceived importance might be due to the ceiling effect [2, 3]. These results confirm that the workshop provided measurable improvements for visualization creators with data visualization accessibility.

2.5.2 Qualitative Results. Overall, participants shared positive reviews about the workshop (*e.g.*, "Great increase in my knowledge" [W9] and "Really enjoyed the workshop" [W10]). W11 appreciated learning about the advantages and shortcomings of modalities:

> `This was a fantastic workshop. I really appreciated being able to think about each approach to creating more accessible visualizations and the pros/cons. I know I've attended a good workshop when I leave`

> with more exciting questions to explore. (W11)

Similarly, W8 said:

> I wasn't sure what to expect. The information gave attainable ways to present data visualizations accessibly and seemed to make the task less daunting. (W8)

W2 recognized an opportunity for the workshop materials to be included in data visualization courses:

> Expectations were met and exceeded! This is so practical and useful! I recently took the Data Viz class and this should be incorporated there. (W2)

Additionally, W6 liked knowing about the state of accessibility:

> This presentation gave me a good sense of what the state of accessibility is with regard to data viz. (W6)

3 DISCUSSION & CONCLUSION

In this work, I organized and conducted a workshop on data visualization accessibility for visualization creators following the guidelines from Sharif *et al.* [22]. Fourteen creators participated in the workshop. I assessed the workshop's impact through pre- and post-workshop questionnaires and analyzed the data using quantitative and qualitative methods. My results show that the workshop enhanced creators' (1) accessibility knowledge, (2) prioritization of implementing accessibility, (3) perceived importance of accessibility, (4) challenges with making visualizations accessible, and (5) desired frequency of conducting studies with screen-reader users by 39%, 15%, 4%, 16%, and 157%, respectively.

I utilized the findings from prior work [22] for implementing an effective workshop. However, I did not conduct multiple variations of the workshop (e.g., one-hour- *vs.* day-long) as my goal was not to identify *the* most effective workshop but rather *one* effective way of conducting workshops. As my work is the first to use the abovementioned metrics to assess a workshop on data visualization accessibility, a baseline comparison was not possible. However, my findings can serve as a baseline for future researchers to perform comparative analyses. Given the varying needs and preferences of creators, I recommend future work to modify the workshop content and structure based on the attendees' preferences.

Although the attendees had diverse educational backgrounds and professions, all were affiliated with . Future work can overcome this limitation by inviting creators with diverse affiliations. Furthermore, future work can also consider conducting workshops for specific demographics (*e.g.,* high school students) by following specialized teaching methods designed for the respective demographic.

ACKNOWLEDGMENTS

This work was supported by the Open Scholarship Commons at the University of Washington. I thank Jacob O. Wobbrock, Joo Gyoeng Kim, Jessie Z. Xu, Robin Chin Roemer, Anissa Tanweer, Verletta Kern, and Andrea Berg for their immense support and guidance. Lastly, I extend our warmest gratitude to Harry and Gemma for their *purr*vasive feline support and cuddles.

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A PARTICIPANTS

Table 3: Gender, age, and education level of the workshop participants.

	Gender	Age	Education Level
W1	Woman	31	Master's
W2	Woman	28	Doctorate
W3	Woman	43	Master's
W4	Woman	24	Bachelor's
W5	Woman	27	Bachelor's
W6	Man	43	Doctorate
W7	Woman	38	Master's
W8	Woman	55	Bachelor's
W9	Woman	45	Master's
W10	Woman	29	Bachelor's
W11	Woman	28	Master's