The Unfortunate Fringes of Visualization Literacy

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Index Terms—information visualization, literacy, education, survey, meta-analysis.

1 Introduction

Written language has been in use for thousands of years. For the majority of its existence, a small set of people were able to understand and construct text. These people were likely wealthy and had access to resources and education that allowed them to learn the skills of reading and writing, otherwise known as literacy. Literacy among the general population has been increasing significantly over the past century due to the increasing accessibility of education. However, this change is still limited to the more privileged portion of the population.

Information, including but not limited to written language, has seen an increase in collection and accessibility in recent history. In order to allow people to understand information, particularly that which is domain-specific, not human-readable, or of large scale, it is increasingly common to visualize it. Additionally, information visualizations are becoming more accessible to the public through their increasingly common use by organizations with large audiences like news outlets and social media pages where they are used for a variety of reasons such as catching users' eyes and quickly communicating summaries of data.

With this method of communicating information comes a new form of literacy: visualization literacy. Analogous to written literacy, early on, visualizations were only comprehensible to highly educated individuals, and now, with their rising popularity, the general population is gaining more exposure. Despite this, visualization literacy in the general public is low [4].

Visualization education is primarily accessible to privileged individuals. While some researchers have addressed this gap in visualization literacy, they often create resources such as online courses taught in English [11] that are inaccessible to those without a strong, consistent internet connection and fluency in English. Further, much of the work into visualization education focuses on teaching young children despite adults likely struggling as well, for example older adults who have difficulty comprehending novel chart types and prefer simple ones, even if considered less effective by the visualization community [8].

The most common theme in the definitions is the ability to read, understand, interpret, or comprehend visualizations [1–6, 9–14]. Second as common is the ability to create or construct visualizations [1, 2, 10]. These two are likely common due to the connection to the traditional meaning of literacy: the ability to read and write. As they have been the most common themes in the existing literature, they have been the most heavily researched and developed. Existing assessments of visualization literacy such as VLAT [11] focus on these two themes and sets of sub-themes have been proposed.

Recent work has dug into parts of visualization that are not explicitly considered visualization literacy but are related. This research focuses on how aspects of socioeconomic status affect the perception of visualizations, engagement and interest in visualizations, and the skill of critical but neutral evaluation of visualizations. This area of work which I will call the fringes of visualization literacy is what I focus on in this work.

The objectives of this paper are as follows: (1) survey existing literature on and (2) discuss themes that lie outside the core of visualization literacy.

2 Related Work

Despite my best efforts, I was unable to find any existing survey papers on visualization literacy. However, some papers that are not primarily survey papers included significant background sections that will be discussed here.

Boy et al. [3] constructed a definition for visualization literacy by starting with the definition of the general term literacy, defined in the Oxford dictionary as "the ability to read and write", and modifying it to be specific to the topic of visualization. They discuss earlier work in the field, such as that in the cognitive processes involved in reading graphs and how it is an iterative process rather than a straight-forward serial process. An interesting finding to come out of this past work is that a person's understanding of a visualization depends on their expertise in the area but that this is less common in more visually literate people. While this work is well cited, it focuses on a narrow, low-level view of visualization literacy.

Börner et al. [2] completed a literature review of visualization literacy as part of their work to develop a framework for research in this topic. They described much of the previous work and noted that none of it explicitly discussed the construction of visualizations. Similar to Boy et al. [3], the focus of this work is on low-level tasks and categorizations.

Peck et al. [13] took a different approach to visualization literacy. They discuss what makes people interested in certain charts and not others and how attention can be improved without employing biased or ineffective visual encodings. These biases may be different or more pronounced in populations that are less literate in visualization than in environments such as universities or large urban centers where design studies are commonly done, even for tools meant for novice users like LineUp [7].

3 Process

For this work, relevant literature from different research venues were found using keyword search and backward and forward chaining from seed papers, then surveyed and analyzed. The seed papers were *Data is Personal: Attitudes and Perceptions of Data Visualization in Rural Pennsylvania* [13] and *A principled way of assessing visualization literacy* [3]. A total of 34 papers that discussed visualization literacy were included. Inclusion criteria was that the paper had some mention of visualization literacy, including using different terms such as "understanding" [15] and "perceptions of" [13] visualization. Papers that did not develop the topic of visualization literacy and only cited it were excluded.

After a preliminary survey, additional papers on the topics of believability of, interest in, and audience of visualizations. The seed papers for these are *Viral Visualizations: How CoronavirusSkeptics Use Orthodox Data Practices toPromote Unorthodox Science Online* [10], *Data is Personal: Attitudes and Perceptions of Data Visualization in Rural Pennsylvania* [13], and *PROACT: Iterative Design of a Patient-Centred Visualization for Effective Prostate Cancer Health Risk Communication* [8] respectively.

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4 FINDINGS

For the following sections, I have formatted my early ideas from the literature as questions to answer when I flesh the sections out.

4.1 Believability

Can people tell when visualizations are misleading? Is this skill learned along with general visualization literacy? Do people have different ideas of what makes a chart misleading? What makes users trust a visualization? Is this trust deserved? Do the factors that go into gaining trust change as a user becomes more experienced?

4.2 Interest

Do people perceive visualizations differently based on their emotions at the time of viewing? When looking at visualizations in a study environment, people tend to make an effort to view them neutrally, is this true when viewing them in more natural environments too? Are those with education around visualization less likely to have emotions affect them during visualizations? Is it ever ethical to manipulate visualizations to cause a certain emotion, and if yes, who decides which scenarios are ethical? What makes someone more engaged in a visualization? Familiarity and relatability improve engagement, but do these compromise on effectiveness? Do those more experienced in visualization engage more equally with visualizations, perhaps spending less time on the exciting but ineffective ones and more time on the boring but important ones?

4.3 Audience

Who are visualizations targeted towards? Do visualizations for the general public take into account true novices? Are people actually illiterate in visualization or do they just use it differently because of personal background?

5 MILESTONES

The updated set of milestones is as follows.

> Oct. 30th: Find as many potentially relevant papers as possible. Skim each one to get a better understanding of what each of them is about and how relevant they are to the survey. Choose about 25 papers to use in the survey. (15 hours) Nov. 10th: Read all papers fully and take notes on each one, including the most relevant sections from each paper. (20 hours) Nov. 16th: Use the notes to generate preliminary findings and create a framework for the paper. (15 hours) Dec 5th: Flesh out the sections to complete the draft. (20 hours) Dec. 12th: Create presentation of survey and findings. (5 hours) Dec. 17th: Finish the paper. (5 hours)

Milestone 1 (M1) is largely complete with 34 papers found for this survey. Some papers may be added or removed later in the writing process. M2 is complete except for a few papers I just found recently and would like to read more thoroughly. M3 is complete in the form of this report. M4 is next, initially in the form of deeper thought about the organization of the findings and developing the findings, discussion, and conclusion.

6 DISCUSSION AND FUTURE WORK

Is today's visualization research really helpful for everyone? Are we really designing for novice users? When should we be calling for better visualization literacy and when should we not? Future work needs to do a better job of studying true novices and underrepresented groups. Something that could be investigated is how these fringes differ among diverse populations.

7 CONCLUSION

34 papers were surveyed and 5 fringe themes were identified and discussed. Three aspects, believability, interest, and audience, were identified that were not typically examined in work on visualization literacy that should be considered in standard visualization literacy research.

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Table 1: Papers considered for survey

Title	First Author	Read?	Used?	Traditional	Believability	Interest	Audience
Understanding visualization through spatial ability differences	Velez	yes	yes	x			
Data is Personal: Attitudes and Perceptions of Data Visualization in Rural Pennsylvania	Peck	yes	yes		x	x	x
A Principled Way of Assessing Visualization Literacy	Boy	yes	yes	x			
Visualization Literacy at Elementary School	Alper	yes	yes	x			
Designing Narrative-Focused Role-Playing Games for Visualization Literacy in Young Children	Huynh	yes	yes		x	x	
Diagram safari: A visualization literacy game for young children	Gabler	yes	yes	x			
Treemap Literacy: A classroom-Based Investigation	Firat	yes	yes	x			
Data visualization literacy: Definitions, conceptual frameworks, exercises, and assessments	Borner	yes	yes	x			
Investigating Aspects of Data Visualization Literacy Using 20 Information Visualizations and 273 Science Museum Visitors	Borner	yes	yes	x		x	
Development of a visualization literacy assessment test	Lee	yes	yes	x			
The Correlation between Users' Cognitive Characteristics And Visualization Literacy	Lee	yes	yes	x			
PROACT: Iterative Design of a Patient-Centred Visualization for Effective Prostate Cancer Health Risk Communication	Hakone	yes	yes				x
Pushing the (Visual) Narrative: The Effects of Prior Knowledge Elicitation in Provocative Topics	Heyer	yes	yes		x		x
Why Shouldn't All Charts Be Scatter Plots? Beyond Precision-Driven Visualizations	Bertini	yes	yes				
The Next Billion Users of Visualization	Jena	yes	yes		x		x
Seeing in Context: Traditional Visual Communication Practices in Rural Bangladesh	Sultana	yes	yes				x
Viral Visualizations: How Coronavirus Skeptics Use Orthodox Data Practices to Promote Unorthodox Science Online	Lee	yes	yes		x	x	x
Smile or Scowl? Looking at Infographic Design Through the Affective Lens	Lan	yes	yes			x	
"It's Just a Graph" – The Effect of Post-Hoc Rationalisation on InfoVis Evaluation	van Koningsbruggen	yes	yes			x	
Influencing visual judgment through affective priming	Harrison	yes	yes			x	
How poor informationally are the information poor? Evidence from an empirical study of daily and regular information practices of individuals	Yu	yes	yes				
Communicating Health Risks With Visual Aids.	Garcia-Retamero						
Helping patients decide: Ten steps to better risk communication.	Fagerlin						
Design Features of Graphs in Health Risk Communication: A Systematic Review.	Ancker						
Effective Communication of Risks to Young Adults: Using Message Framing and Visual Aids to Increase Condom Use and STD Screening.	Garcia-Retamero						

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Title	First Author	Read?	Used?	Traditional	Believability	Interest	Audience
Reducing the Influence of Anecdotal Reasoning on People's Health Care Decisions: Is a Picture Worth a Thousand Statistics?	Fagerlin						
A demonstration of less can be more' in risk graphics.	Zikmund-Fisher						
Improving understanding of adjuvant therapy options by using simpler risk graphics.	Zikmund-Fisher						
Evaluation of Artery Visualizations for Heart Disease Diagnosis.	Borkin						
How well do health professionals interpret diagnostic information? A systematic review.	Whiting						
Rethinking Health Numeracy: A Multidisciplinary Literature Review.	Ancker						
How numeracy influences risk comprehension and medical decision making.	Reyna						
Measuring numeracy without a math test: development of the Subjective Numeracy Scale.	Fagerlin						
Graph Literacy: A Cross-Cultural Comparison.	Galesic						