Extended Abstract for the
Symposium on Integrating AI and Data Science into School Education Across Disciplines 2025

RESEARCH TO PRACTICE: DESIGNING LEARNING EXPERIENCES FOR TEACHERS AROUND READING THE WORD AND THE WORLD WITH DATA VISUALIZATIONS

Travis Weiland
University of North Carolina Charlotte, United States, tweilan1@charlotte.edu

Focus Topics: AI and Data Science Curricula and Implementation in School and AI and Data Science Education for Social Good

Rationale and Aims

Data visualization is a core aspect of data science and reading data visualizations can be found across the K-12 school curriculum in many countries. There is a long lineage of scholarship on how people make sense of graphs in statistics (Friel et al., 2001; Shaughnessy, 2007). However, the types of data visualizations used in today's media and more commonly associated with data science have different affordances than the graphs that have typically been studied in mathematics and statistics education work in the past (Lim et al., 2023). The aim of this paper is to present initial work on a research to practice design research project that has been conducted over the past five years focused on making sense of and supporting mathematics teachers in reading data visualizations and creating activities for their students to make sense of data visualizations.

Design Overview

This work is part of a design research project focused on developing mathematics teacher's critical statistical literacy (Weiland, 2017) for doing and teaching statistics and more recently data science. Critical statistical literacy draws upon the work of Paulo Freire (Freire, 1970; Freire & Macedo, 1987) to imagine what reading and writing the world with data looks like intersecting practices from critical literacy/theory and statistical literacy. In thinking about taking a philosophical end goal like the practices outlined in critical statistical literacies and putting them into practice we created a theory of change based on sociocultural and sociopolitical theories of learning shown in Figure 1. We draw from Freire's notion of generative themes to serve as the spark for learning. Freire use community circles with picture cards that had pictures that depicted scenes from people's everyday lives that they could then have conversations around, drawing from people's reading of the world. From there we would then ad words to the discussions to bring in the technical side of literary work in reading the word. This is an important first step to a process of then writing the word and in term writing the world enacting broader social and structural change for more just futures.

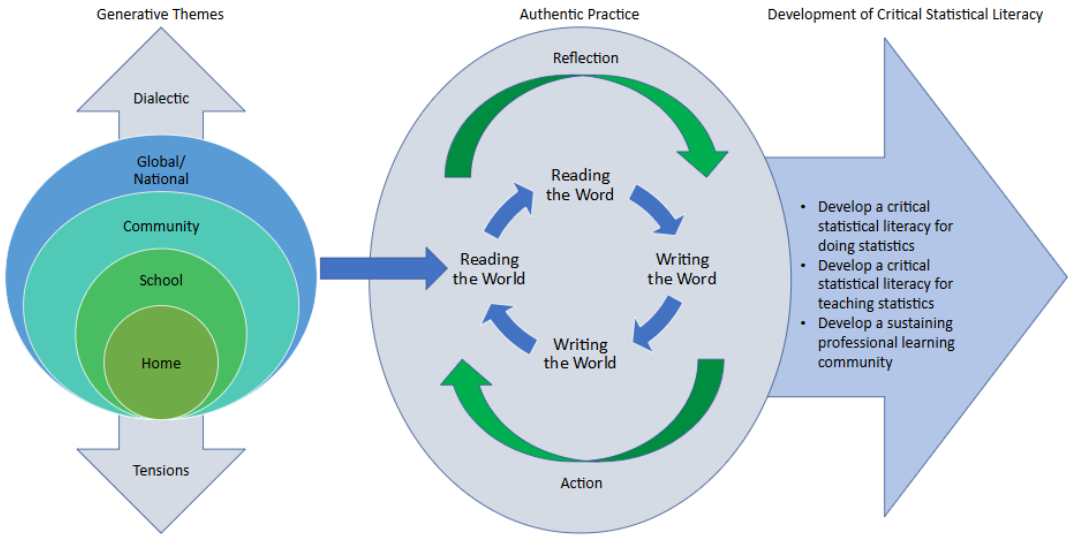

Figure 1: Theory of change for design research project

In S. Podworny & S. Schönbrodt (Eds.), *Towards Fostering AI and Data Science Literacy in Schools Across Disciplines. Proceedings of the 1st Symposium on Integrating AI and Data Science into School Education Across Disciplines (AIDEA1 2025)*, Salzburg, Austria.

We decided in our design work to begin by focusing on reading data visualizations which is one of the most common ways we read statistics/data in our daily lives. To build from prior research we started using the levels of reading graphs described by Friel et al. (2001) and expanded upon by Shaughnessy (2007) in conjunction with the reading practices Weiland (2017) described in critical statistical literacies to create an initial one-dimensional framework.

Pilot Study

To begin to explore how teachers read data visualizations we started by using graphs from the New York Times What's going on in this Graph column that uses data visualizations from the newspaper as a discussion point for students. We kept the questions typically asked in the NYTs column and added a couple of our own which we then assigned to teachers in a graduate course on teaching statistics. Eight teachers participated in three discussion board activities where they had to make sense of the graph themselves and then also engage in dialogue with the other teachers and how they made sense of the graph. From this initial work we found that our initial framework was not sufficient to make sense of the data in several ways. One way was that the practices that Weiland (2017) describes are very top level and theoretical, which was not sufficient for making sense of the nuances in teachers statements specific to reading data visualizations. Another issue we encountered was that our framework did not adequately capture teachers' progress toward critical statistical literacy but instead mostly just captured their reading of the graphs in a technical disciplinary sense.

Revisions

Our pilot work happened to coincide with the pandemic when many educational researchers were becoming keenly aware of the issues with reading the data visualizations related to the pandemic that were not well studied in the literature leading to a wave of publications on reading data visualizations (Bailey & McCulloch, 2023; da Silva et al., 2021; Lim et al., 2023; Rubel et al., 2021). We then went back to our framework using recent studies to create a two-dimensional framework that is non-hierarchical. One dimension focuses on types of reading drawing from the prior research on level of reading graphs, which include reading the data, reading between the data, reading beyond the data, and reading behind the data. The other dimension is focused on the notion of reading the word and the world from Freire's literacy work (Freire, 1970; Freire & Macedo, 1987).

Question	WORD				WORLD			
	Reading the Data	Between	Beyond	Behind	Reading the Data	Between	Beyond	Behind
What do you notice?	10	11	3	0	0	0	3	0
What do you wonder?	0	1	0	10	1	5	4	6
Create a catchy headline that captures the graph's main idea.	1	3	13	0	0	0	7	0
What relationship(s) is the author highlighting?	3	16	7	0	0	0	2	0
What is a claim you could make from this data visualization?	2	7	14	0	0	0	2	0
What evidence are you using to make this claim?	13	14	2	0	0	0	2	0
How does this relate to you and/or your community?	0	0	2	0	4	4	9	1

Table 1: Counts of codes utterances from participants related to the levels of reading and reading the word and the world

We first coded the data again looking at reading the word and the world through the lens of the types of reading shown in Table 1. We later reimagined reading the word and the world in the context of data literacy with the help of Lee et al.'s (2021) framework for humanizing data science education with the layers of reading the word, reading the world personal, and reading the world sociopolitical. Another issue we discovered when we recoded our data was that the questions we asked were related to the types of reading that participants engaged in as shown by the shared regions in Table 1. This made us start to think about what questions would help support different types of reading that we could then provide to teachers as a starting point for designing their own activities while also driving our design with teachers.

Main Study

Our main study of teachers' development of critical statistical literacies began with a two-week summer workshop in the summer of 2023. Using the redesigned framework, we redesigned the types of activities we were using to engage teachers in reading data visualizations which we then analyzed data from using the new framework to test theory in practice. We have found the framework to be stabilizing with our data analysis as we look between theory in practice. We are now using it to analyze the sequence of 7 activities embedded in a two week professional development that was conducted with a professional learning community of nine secondary mathematics teachers to trace their reading of the data visualizations to look for their own development of practices and the connection between use of practices and the activity itself in hopes that we will gain insights into how to better design professional learning experience for supporting teachers reading of data visualizations.

In redesigning our activities, we now view data visualizations like Freire's picture cards he used in his community circles. Therefore, we intentionally chose data visualization of issues that our participants would have some learned experiences around to draw upon. For example, Figure 2 shows the first data visualization we use in our sequence of activities which was created by the Department of Public Instruction in North Carolina where the participants were teachers. It was related to their daily lived experience but was also designed with a political message in mind which the teachers picked up on immediately and sparked discussions. The political message was that teachers are paid well and do not need raises in salary. The statistical concept that was related to this message is the difference in how mean and median are impacted by skewed distributions. Basically, you cannot compare the mean of one heavily skewed distribution to the median of another. We also purposefully asked questions that were related to different reading types and then explicitly described those types of reading to the teachers.

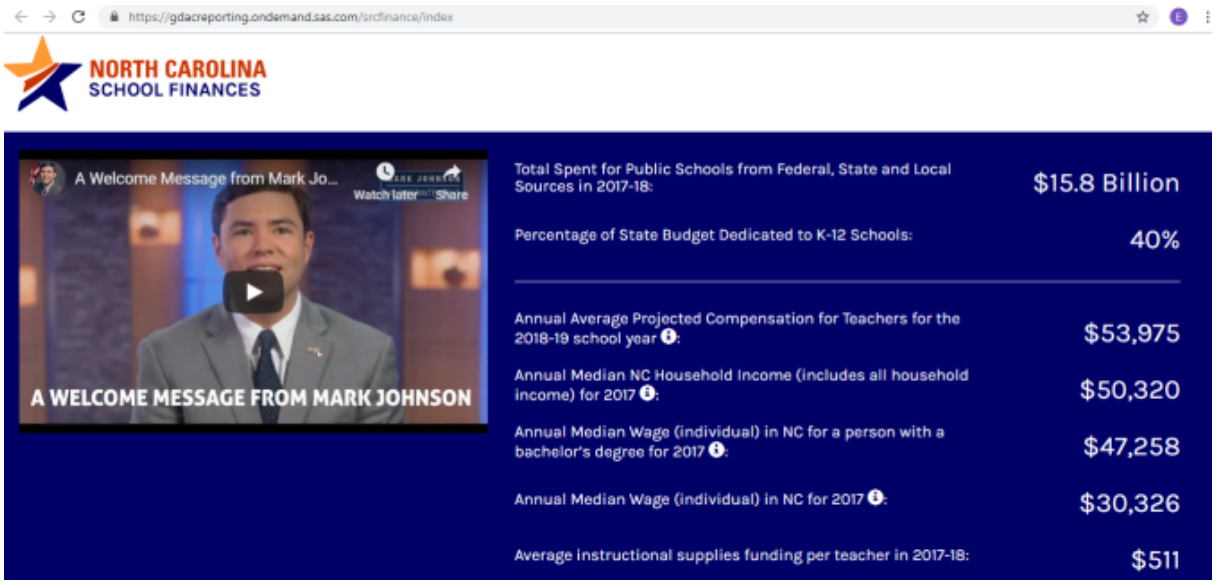

Figure 2: Screenshot of the data visualization we used in the first data visualization activity participants engaged in for the professional learning community

From our analysis using our redesigned framework was that we saw significant shifts in terms of the types of reading teachers were engaging in with the focus predominantly around reading the world (see Table 2) whereas in our pilot study much of the reading was more focused on reading the word. What we are working on now is coding the data to look for shifts across all of the data visualization activities to look for connections between the design of the activity and teachers reading of types to see if we can find profiles of reading and also look for underlying design principles specific to reading data visualizations.

Stage of Activity	Word				World Personal/Community				World Sociopolitical			
	Reading the Data	Between	Beyond	Behind	Reading the Data	Between	Beyond	Behind	Reading the Data	Between	Beyond	Behind
Notice, Wonder, Community	9	1	0	3	1	1	5	5	3	9	10	10
Read the Data	0	0	0	0	5	2	3	2	0	2	4	1
Read between the Data	5	1	0	0	0	2	7	4	0	0	4	4
Read Beyond the Data	0	1	0	7	0	0	6	3	0	2	5	2
Read Behind the Data	0	0	0	3	0	0	0	1	0	3	3	5
Reflection	0	0	0	0	0	0	0	0	0	0	0	1

Table 2: Counts of utterances by stage of activity and reading the word and world through data visualizations framework

Conclusions

In conclusion, we have found that our framework is becoming stable in our research and show promise for use in other settings. We are also finding important aspects of our design and we are connecting them to the research literature. In particular, viewing data visualizations as picture cards of generative themes for data visualization literacy development seems to hold promise for supporting teachers' developments of critical statistical literacies. One major challenge we have found is getting teachers to translate their learning into teaching practice with their own students, which is something we continue to work on. Another issue is how much do teachers need to know about the creation (writing) of data visualizations to be able to critically read them? This is still an open question for us and an important one we think for others to consider as well.

Acknowledgement

This material is based upon work supported by the National Science Foundation under DRK-12 Grant #2143816. Any opinions, findings, and conclusions or recommendation expressed in this material are those of the author and do not necessarily reflect the view of the National Science Foundation.

References

Bailey, N. G., & McCulloch, A. W. (2023). Describing critical statistical literacy habits of mind. *Journal of Mathematical Behavior*, *70*. https://doi.org/10.1016/j.jmathb.2023.101063

da Silva, A. S., Barbosa, M. T. S., de Souza Velasque, L., da Silveira Barroso Alves, D., & Magalhães, M. N. (2021). The COVID-19 epidemic in Brazil: How statistics education may contribute to unravel the reality behind the charts. *Educational Studies in Mathematics*, *108*(1–2), 269–289. https://doi.org/10.1007/s10649-021-10112-6

Freire, P. (1970). *Pedagogy of the oppressed*. Continuum.

Freire, P., & Macedo, D. (1987). *Literacy: Reading the word and the world*. Taylor and Francis.

Friel, S. N., Curcio, F. R., & Bright, G. W. (2001). Making sense of graphs: Critical factors influencing comprehension and instructional implications. *Journal for Research in Mathematics Education, 32*(2), 124–158. https://doi.org/10.2307/749671

Lee, V. R., Wilkerson, M. H., & Lanouette, K. (2021). A Call for a Humanistic Stance Toward K–12 Data Science Education. *Educational Researcher, 50*(9), 664–672. https://doi.org/10.3102/0013189X211048810

Lim, V. Y., Peralta, L. M. M., Rubel, L. H., Jiang, S., Kahn, J. B., & Herbel-Eisenmann, B. (2023). Keeping pace with innovations in data visualizations: A commentary for mathematics education in times of crisis. *ZDM – Mathematics Education, 55*(1), 109–118. https://doi.org/10.1007/s11858-022-01449-0

Rubel, L. H., Nicol, C., & Chronaki, A. (2021). A critical mathematics perspective on reading datavisualizations: Reimagining through reformatting,reframing, and renarrating. *Educational Studies in Mathematics, 108*, 249–268. https://doi.org/10.1007/s10649-021-10087-4

Shaughnessy, M. (2007). Research on statistics learning and reasoning. In F. K. Lester (Ed.), *Second handbook of research on mathematics teaching and learning* (pp. 957–1009). Information Age Publishing.

Weiland, T. (2017). Problematizing statistical literacy: An intersection of critical and statistical literacies. *Educational Studies in Mathematics, 96*(1), 33–47. https://doi.org/10.1007/s10649-017-9764-5