

## TOWARDS A FRAMEWORK FOR A CRITICAL STATISTICAL LITERACY IN HIGH SCHOOL MATHEMATICS

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*In the spirit of questioning, crossing, and blurring disciplinary borders with(in) mathematics education, this paper proposes a theoretical framework that merges conceptions of critical literacy and statistical literacy for high school mathematics curriculum. I begin by discussing the political nature of education and then situate this work within the goals of education for active citizenship. Next, I provide a detailed background of both critical and statistical literacy from multiple educational research perspectives. Lastly, by synthesizing notions of critical and statistical literacy, I present a theoretical framework for a critical statistical literacy in the context of high school mathematics curriculum.*

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### Introduction

In modern society, which is drenched in data (Steen, 2001), individuals need to be statistically literate (Gal, 2004). There has been an explosion of data in every facet of life including medicine, economics, education, and public opinion, just to name a few (Ben-Zvi & Garfield, 2008). As a result statistical literacy is becoming a crucial literacy for being a citizen in today's modern societies. As Franklin et al. (2007) states, "every high school graduate should be able to use sound statistical reasoning to intelligently cope with the requirements of citizenship" (p.1). However, it is important for citizenship education that this literacy goes beyond the tradition 'consumption and production' conception of statistical literacy (Ben-Zvi & Garfield, 2004; Franklin et al., 2007; Gal, 2004) to include fostering sociopolitical awareness and critique. Large scale social and environmental issues, such as racism, climate change, refugee crises, and poverty need to be addressed in school curriculum so that students are not only aware of them, but have experiences investigating them (Apple & Beane, 2007). In this way, schools can serve as sites for fostering students/citizens, who can thoughtfully engage issues in their local and global community for the purposes of creating a more just world for tomorrow.

Today in the context of secondary education in the United States, the teaching of statistics and data analysis is situated in the mathematics curriculum (National Council of Teachers of Mathematics [NCTM], 2000; National Governors Association Center for Best Practices [NGA] & Council of Chief State School Officers [CCSSO], 2010). As data analysis and statistical methods have gained importance in society, they have also gained emphasis in the standards for mathematics instruction in grades 6-12, for example, with the introduction of the *Common Core State Standards for Mathematics* (NGA & CCSSO, 2010). Unfortunately, situated in this context statistics concepts and practices are frequently reduced to mundane computations (Cockcroft, 1982) stripping them of the power they have in investigating issues that are meaningful to students lives as well as their historical and sociopolitical contexts. In the K-12 context there needs to be an emphasis put on teaching statistical concepts and practices consistent with the discipline of statistics, and that will be useful when investigating sociopolitical issues that are prevalent in the world today. To engage in active, critical citizenship, students need a critical statistical literacy.

Before I elaborate on what I mean by a critical statistical literacy I will situate this idea in the broad sociohistorical and political context of US education. I will also draw from multiple discourses

concerning literacy to position this form of literacy, and rationalize its importance in education, and more specifically mathematics education.

### **The Political Nature of Education and Citizenship**

Education is inherently political in that organizations and individuals make decisions on what topics, issues, and concepts are learned, and who can learn them, therefore endorsing certain ideas, views, and individuals, while disadvantaging and excluding others. As Labaree (1997) argues, “the central problems with American education are not pedagogical or organizational or social or cultural in nature but are fundamentally political” (p.40). The problem is rooted in differing, and at times competing, goals of education. Labaree argues that one of the predominant goals of US education is democratic equality. Americans take great pride in living in a democracy, where decisions are made by the people, for the people. Education centered on citizenship benefits society by fostering a literate and educated citizenry who can make critical decisions, and in turn create a stronger democratic society for all. I firmly believe in this goal for education, viewing it as a public good, preparing youths to take up the role of citizens (Apple & Beane, 2007; Giroux, 1989; Labaree, 1997); and it is upon this goal that I situate this paper.

There are many views of what constitutes “good” citizenship, which are culturally, socially, and historically situated. These views can be roughly categorized into three main types of citizenship: personally responsible, participatory, and justice oriented, as described by Westheimer and Kahne (2004). The image of a personally responsible citizen is a hard working individual who follows the law, has good character, and is responsible in his/her community. As indicated by its name, the participatory vision of citizenship is one where citizens are active participants in the government and community. They work within the system to try to improve conditions. The third view of what makes a “good” citizen is the justice oriented citizen. “Good” citizens in this view are ones who question and critique the injustices of societal structures. This type of citizen seeks to find and address the root causes of injustices in society as well as engage in activism, and leverage social movements, to effect systemic change.

There are strengths and weaknesses to each of these views of citizenship. For example, in the personally responsible view of citizenship there is no active participation in government/community affairs, or working to change unjust laws, inequities, etc. This type of citizenship maintains the status quo. The problem with this mentality is that the status quo today includes unjust structures of racism, classism, and sexism that favor certain individuals and disadvantage others (Giroux, 1989; Knoblauch & Brannon, 1993). For example, wealth is becoming increasingly polarized with a small number of individuals holding the majority of the wealth, and an increasingly large proportion of the population sinking into poverty based on hegemonic economic structures (Brown, 2006). I see the ideal view as a blending of participatory and justice-oriented. In my opinion, a good citizen should participate actively in their community and/or government, but should also interrogate the structures at play within their community and government, which produce conditions of injustice, and actively work to change those that (re)produce injustices. Giroux (1989) describes this type of citizenship in his view of education for democracy. One of the key aspects of this view of citizenship that Giroux describes is that,

It is important to acknowledge that the notion of democracy cannot be grounded in some ahistorical, transcendent notion of truth or authority. Democracy is a "site" of struggle, and as a social practice is informed by competing ideological conceptions of power, politics, and community. This is an important recognition because it helps to redefine the role of the citizen as an active agent in questioning, defining, and shaping one's relationship to the political sphere and the wider society. (p.28-29)

I agree with this view of democracy, as a site of struggle, and with citizens as active agents in shaping the meaning of democracy. In today's modern societies, there are a plurality of different views, values, and ideas, which citizens must be able to negotiate and navigate in daily life. Furthermore, strengthening the bonds between fellow citizens through a common goal of democracy, while appreciating the plurality inherent in our society, is also crucial to being a citizen (Giroux, 1989). I will henceforth refer to this participatory and justice oriented view of citizenship for democracy as *critical citizenship*.

Education based on critical citizenship would include learning both how institutions works, and how to critique and change them, as well as the historical, social and political discourses that shape society and the views of citizens. Students would be provided opportunities to give back to their communities, and encouraged to take action, by forming and leading their own efforts to fight injustices they see in the world around them. An example of this view of citizenship being played out in the context of mathematics education can be seen in Gutstein's (2006) descriptions of his teaching in a Chicago public middle school. Gutstein showed students how to participate in their community and government by taking them to town hall meetings, and also provided them with experiences in using mathematics to investigate injustices related to racist policing practices and gentrification present in their community. It is in this direction, I believe education needs to go, to educate students to function in society, as well as participate in shaping, and improving society for future generations. Critique is an important aspect in this type of education, but as Giroux (1989) points out, "the discourse of democracy also needs a language of possibility, one that combines a strategy of opposition with a strategy for constructing a new social order" (p. 31). It is important for students to have experiences critiquing and analyze discourses and institutional structures, however it is equally important for them to have experiences shaping and creating just practices for the wellbeing of others, in their local and global communities. It is in dialogue between these two types of experiences that schools can help students learn about democracy as a site for struggle, in constant negotiation by citizens who actively participant in creating it. One possible approach that Giroux (1989) describes for making pedagogy more political, for the purposes of educating for a critical citizenry, is to organize pedagogy around critical literacy. Literacy is already a predominant goal of education. Therefore, a critical literacy can be an entry point into school curriculum for the purposes of fostering critical citizens.

I have laid out my view of education, which I see as a public good that should promote critical citizenship for participation in democratic societies. Based on this view of education I will now describe what I mean by a critical statistical literacy, and why it is an important literacy to foster in secondary school classrooms.

### **Literacy**

The theme of literacy has been an educational focus for some time, and has had an ever-changing history. Literacy is commonly defined around the acts of reading and writing (Gee, 2014; United Nations Educational, Scientific, & Cultural Organization [UNESCO], 2005). However the commonalities generally end there. One large difference in scholars' interpretations of literacy is whether the focus should be on the skills necessary to read and write (Scribner, 1984), or on the practices of reading and writing themselves (Perry, 2012). Another aspect of the literature on literacy that varies greatly is the *object* of reading and writing. Much literacy work has focused on the reading and writing of the written languages, in the dominant language of the community in which an individual is a member (Freire & Macedo, 2003; Scribner, 1984; UNESCO, 2005). Overtime, this has expanded to include a multitude of different types of literacy such as financial, quantitative, digital, media, and technological literacies. In this section, I will discuss two types of literacy, statistical and critical, and propose a framework for merging the two types of literacy into a critical statistical literacy. As a note, there is a large research base around quantitative and mathematical

literacies that intersects with statistical literacy. However, I am making a political choice not to draw upon this work, but to instead explicitly draw upon statistical literacy work, which is deeply situated in statistics education and the discipline of statistics, to emphasize its importance, so it is not easily subsumed in the high school mathematics curriculum.

### **Critical Literacy**

Critical literacy draws from a sociocultural definition of literacy in that it is viewed as the practices and abilities associated with being literate. Scholars of critical literacy also foreground the connection between literacy and power (Lankshear & McLaren, 1993). Many discuss literacy as an emancipatory force (Darder, 2014; Freire, 1970; Freire & Macedo, 2003; Giroux, 1989, 1993; Gutstein, 2006), beginning with learning to read the word *and* the world, which can then lead to individuals to being able to write both the word and world—transforming their lived realities through the power of literacy. When democracy is viewed as a site for struggle, through the dialogue of a plurality of views, literacy for critical citizenship needs to include the practices of critiquing and interrogating the discourses and structures in society that reproduce oppressions and injustices. As Gutstein (2006) points out, “U.S. schools socialize students into non-questioning roles, creating and maintaining passive identities so that students do not believe in their own power to shape the world” (p.88). It is in shifting this dominant form of socialization in American schools that the work of critical literacy scholars can speak volumes. By providing students experiences to see how they are situated by social structures, and also how their own schooling is shaped by historical, political, and socially constructed institutions and discourses, can help students create and maintain active citizen identities, where they believe in their own power to influence and shape the world. Without such socialization, how can we ever expect students to become active participants in their communities, to become critical citizens working to negotiate and shape the democracies they live in? As Giroux (1989) describes,

Critical literacy can provide the theoretical basis for presenting students with the knowledge and skills necessary for them to understand and analyze their own historically constructed voices and experiences as part of a project of self and social empowerment. Central to this view of literacy is an understanding of how knowledge and experience are constructed around particular forms of intellectual, moral, and social regulation within the various relations of power that characterize schools, families, workplaces, the state, and other major public spheres. (p. 34)

Bringing critical literacy into schools can help prepare students to be critical citizens in democratic societies actively participating in the struggle to (re)define meaning and principles of democracy in their world. An important aspect of literacy for critical citizenship includes a statistical literacy, which I will spend some time describing in the next section.

### **Statistical Literacy**

Similar to other types of literacy, statistical literacy can be viewed in terms of reading and writing. The difference is that while literacy is typically considered as reading and writing the written symbol system of the dominant language of a community that an individual is a member of (Freire & Macedo, 2003; Scribner, 1984; UNESCO, 2005), statistical literacy is based on reading and writing a *specialized* symbol system, socially constructed by the discipline of statistics. The practice of reading and writing statistics draws on the dominant language of a social group, but also relies on a specialized symbol system that includes quantities and mathematical symbols, as well as symbols specific to the discipline of statistics. For example, the symbol  $\bar{x}$  in statistics represents the arithmetic mean of a sample of data points. However, by itself, the quantity that represents the mean of a data set is relatively meaningless without using it in context, which requires using the dominant language of the individuals which the information is being presented to. For example, the mean

salary for public school teachers in Massachusetts was \$73,908 in the 2013-2014 school year (Massachusetts Department of Elementary and Secondary Education, n.d.). The quantity 73,908 is relatively meaningless until the English language is used to describe and give context and meaning to the quantity.

In the data drenched societies of today, it is crucial for students to be educated and critical consumers of data based arguments (Ben-Zvi & Garfield, 2008; Franklin et al., 2007; Steen, 2001). Citizens today need to be able to make sense of, and critically evaluate, the validity and usefulness of the information presented in statistical arguments, and make informed decisions based on the arguments presented. Reading statistical arguments is a key element of statistical literacy (Franklin et al., 2007; Gal, 2004). Gal's (2004) definition of statistical literacy describes this element well shown here:

(a) people's ability to interpret and critically evaluate statistical information, data-related arguments, or stochastic phenomena, which they may encounter in diverse contexts, and when relevant (b) their ability to discuss or communicate their reactions to such statistical information, such as their understanding of the meaning of the information, their opinions about the implications of this information, or their concerns regarding the acceptability of given conclusions. (p.49)

Reading is only one part of literacy however; there also needs to be a writing component, as the two have a dialogical relationship with one another, just as reading the word and the world operate in dialogue. Writing in statistics involves actively investigating a phenomenon through a statistical investigation, and communicating the results of that investigation to others. The *Guidelines for Assessment and Instruction in Statistics Education (GAISE)* framework (Franklin et al., 2007), outlines four components of the statistical investigative cycle: formulate questions, collect data, analyze data, and interpret results. In drawing from this description of the statistical investigative cycle, writing statistics could be defined as,

The ability to formulate statistical questions, collect or find data relevant to statistical questions, analyze data using appropriate graphical and numerical methods, and interpret analyzed data addressing the statistical question(s) being investigated.

Combining this description of writing statistics with the earlier description of reading statistics from Gal's (2004) definition of statistical literacy, creates a coherent description of statistical literacy, that includes both the elements of reading and writing, consistent with the broader field of literature around literacy. This also provides a view of statistical literacy that can be merged with the earlier described view of critical literacy, centered on reading and writing.

### **Critical Statistical Literacy**

Now that I have situated the focus of this work, I think it is time I provide a description for what I am calling critical statistical literacy. I see this concept as an intersection of critical and statistical literacies. My goal here is to emphasize the importance of some powerful statistical ideas that are crucial to a critical literacy in democratic education. I have used the word critical first in order to foreground a critical literacy perspective, which is important across all curricula in education, because it is rooted in practices for participating in, critiquing, and (re)shaping structures and discourses in society that are crucial for critical citizenship in society. Next, I have used the word statistics, which is important to emphasize in the high school mathematics context, because it is a distinct discipline (Franklin et al., 2007) whose concepts and practices frequently get subsumed in the school mathematics curriculum, and stripped of their power, reduced to a litany of calculations (Cockcroft, 1982).

**Table 1: Framework for a Critical Statistical Literacy**

	<b>Read</b>	<b>Write</b>
<b>Statistical Literacy</b>	<ul style="list-style-type: none"> <li>• Making sense of and critiquing statistical information and data based arguments encountered in diverse contexts.</li> <li>• Discussing or communicating the meaning of statistical information.</li> <li>• Evaluating the source, collection and reporting of statistical information.</li> </ul>	<ul style="list-style-type: none"> <li>• Formulating statistical questions.</li> <li>• Collecting or finding data relevant to answering posed statistical question(s).</li> <li>• Analyzing data using appropriate graphical and numerical methods.</li> <li>• Interpreting analyzed data addressing the statistical question(s) being investigated.</li> </ul>
<b>Critical Literacy</b>	<ul style="list-style-type: none"> <li>• Making sense of symbol systems.</li> <li>• Identifying and interrogating social structures in the world.</li> <li>• Gaining an awareness of sociopolitical issues in society.</li> <li>• Gaining an awareness of the dialectical tensions in society</li> <li>• Understanding one’s social location, subjectivity, political context and having a sociohistorical and political knowledge of self and world.</li> </ul>	<ul style="list-style-type: none"> <li>• Creating and communicating one’s own meaning through symbol systems.</li> <li>• Actively influencing and shaping structures in society.</li> <li>• Working to alleviate and resolve sociopolitical issues of injustice.</li> <li>• Actively negotiating and navigating dialectical tensions in society.</li> <li>• Communicating one’s social location, subjectivity, and political context to others and how it influence and shapes one’s meaning making of the world.</li> </ul>
<b>Critical Statistical Literacy</b>	<ul style="list-style-type: none"> <li>• Making sense of language and statistical symbols systems and critiquing statistical information and data based arguments encountered in diverse contexts to gain an awareness of sociopolitical issues in society.</li> <li>• Identifying and interrogating social structures which shape and are reinforced by the data based arguments being considered.</li> <li>• Understanding one’s social location, subjectivity, political context and having a sociohistorical and political knowledge of self and understanding how it influences one’s interpretation of information.</li> <li>• Evaluating the source, collection and reporting of statistical information and how they are influenced and shaped by the author’s social position and sociopolitical and historical lens.</li> </ul>	<ul style="list-style-type: none"> <li>• Using statistical investigations to communicate statistical information and arguments in an effort to destabilize and reshape structures of injustice for a more just society.</li> <li>• Using statistical investigations to alleviate and resolve sociopolitical issues of injustice</li> <li>• Negotiating societal dialectical tensions when formulating statistical questions, data collection and analysis methods and highlighting such tensions in the results of a statistical investigation.</li> <li>• Communicating one’s social location, subjectivity, and political context to others and how it shapes one’s meaning making of the world when reporting results of a statistical investigation.</li> </ul>

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Beginning with the element of reading, a critical statistical literacy would include: i) making sense of language and statistical symbols systems; ii) critiquing statistical information and data-based arguments encountered in diverse sociopolitical contexts; iii) gaining an awareness of sociopolitical issues and social structures in society; iv) interrogating discourses and social structures that are shaped and reinforced by data based arguments; v) understanding one's own social location, subjectivity, and political context to develop a sociohistorical and political knowledge of self, and how it influences one's interpretations; vi) evaluating the source, collection, and reporting of statistical information, and how they are influenced and shaped by the authors social position and broader discourses, institutions, and historical forces

Moving from reading to writing shifts the focus from being an active and critical consumer of statistical information and arguments to being a producer of statistical information and arguments. Writing within a critical statistical literacy would include: i) using statistical investigations to communicate statistical information and arguments, in order to question and reshape institutions and social structures; ii) using statistical investigations to alleviate and resolve sociopolitical issues of injustice; iii) negotiating and navigating dialectical tensions in society when formulating statistical questions, data collection, and analysis methods, and furthermore explicitly discussing these tensions related to, for example, objective versus subjective truths, or constructed categories versus continuous scales (e.g. gender, race/ethnicity, etc.), in the communication of the results of a statistical investigation; iv) communicating one's social location, subjectivity, and political context to others, and describing how it influences and shapes one's meaning making of the world, when reporting results of a statistical investigation.

A critical statistical literacy based on the elements I have described of reading and writing are summarized in Table 1. This type of literacy is crucial to critical citizenship in today's data centric societies. Statistics is now part of many of the dominant discourses of society, which critical citizens must critically make sense of and evaluate. Furthermore, because of statistics position of power in dominant discourses for providing 'evidence of truth,' it is crucial for critical citizens to be able to use that power to influence, shape, and transform the socially constructed discourses and structures around them in order to create a more just world.

### Implications

If schools are to prepare students to tackle large scale social issues, they need to be addressed in school curriculum so that students are both aware of, and have experiences investigating, them (Apple & Beane, 2007). Going forward, I see two major hurdles in fostering a critical statistical literacy in secondary school mathematics curriculum. As I described earlier, critical statistical literacy draws from two main discourses, statistical literacy and critical literacy, neither of which is common in secondary mathematics curriculum. For students to develop sociopolitical awareness and the tools necessary to read and write the world with statistics as critical citizens, they need to have access to powerful statistical ideas. Furthermore, they need to have experiences using those practices and concepts to explore and interrogate structures and injustices in society, to foster sociopolitical awareness, and the practices of critique and active citizenship. I think the following statement by Giroux (1993) concerning critical literacy is quite appropriate for the critical statistical literacy I am proposing as it fits within the theme of questioning borders with(in) mathematics education,

The pedagogical and ethical practice which I am emphasizing is one that offers opportunities for students to be border crossers; as border crossers, students not only refigure the boundaries of academic subjects in order to engage in new forms of critical inquiry, but they are also offered the opportunities to engage the multiple references that construct different cultural codes, experiences, and histories. (p. 375)

The critical statistical literacy framework proposed here is by no means complete. There are many questions that need to be considered, such as what does a curriculum that fosters such a literacy look like? How would such a curriculum be enacted in the classroom? How do we train and prepare teachers to teach such a curriculum, especially when situated in high school mathematics where many teachers have had little past experience with statistics (Shaughnessy, 2007)? These are but a few of the many questions that could be posed based on this framework.

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