Integrating Critical Numeracy and Critical Literacy in K-8 Classrooms

David J. Whitin[1], Phyllis Whitin[2]
[1]Wayne State University, College of Education, 5425 Gullen Mall, Detroit, MI 48202
[2]Wayne State University, College of Education, 5425 Gullen Mall, Detroit, MI 48202

Abstract
Fostering a skeptical attitude toward data texts is an essential habit of mind for elementary school students. The authors show how even young children can be supported to critique, interrogate and challenge such texts. After examining perspectives from mathematics and literacy theory and pedagogy, they present a heuristic that outlines key questions that teachers can pose to promote this questioning stance. In the context of these questions, classroom examples highlight two important strategies: 1) Displaying the same set of data in two different ways and then examining what relationships are revealed and concealed by each; 2) Brainstorming alternative ways to pose a question, define a term, and categorize responses, and then examining the possible effects for each of these possibilities. The examples show the application of these strategies across the curriculum: social statistics, science, health, and economics.

Key Words: Statistical literacy, elementary school, critical numeracy

1. The State of Statistical Education

Statistical literacy has been receiving increased attention during this past decade. With the publication of its *Principles and Standards for School Mathematics* (2000) the National Council of Teachers of Mathematics included “Data Analysis and Probability” as one of its key mathematical standards for PreK-12 education. It calls for students to be competent in devising appropriate questions, selecting methods to analyze their data, and developing inferences and predictions to evaluate that data. In 2007 the American Statistical Association published its *Guidelines for Assessment and Instruction in Statistics Education (GAISE) Report* (Franklin, Kader, Mewborn, Moreno, Peck, Perry & Scheaffer). It describes the permeation of statistical information in every facet of people’s lives and calls for a comprehensive PreK-12 statistical curriculum of increasing depth and sophistication.

However, despite this recognition of the importance of statistical education, each of these national reports falls short in its recommendations. Although NCTM’s report does highlight the need for statistical literacy in the elementary grades by devoting sections to preK-2 and grades 3-5, it does not underscore the critical attitude toward statistical texts that all students must develop. The GAISE Report does acknowledge more explicitly the importance of a skeptical stance toward data texts but its recommendations seem to be more directed at middle/high school teachers with little attention paid to elementary education. The purpose of this paper is to emphasize these two main points that do not always garner the attention they deserve:

- Statistical literacy must begin in the earliest grades.
- Adopting a critical orientation toward statistical texts is an essential habit of mind for all learners.

These two foci are not separate objectives but need to be viewed as a singular goal, i.e. fostering a healthy skepticism toward statistical texts in the elementary grades. This goal is also one that cuts across all subject fields. A skeptical stance involves several important dispositions that include: raising questions, uncovering assumptions, interrogating conclusions, challenging authoritative sources, seeking out alternative interpretations, exposing decisions, and so on. The importance of this critical attitude is not new. Dewey cites critical attitudes, such as posing questions, suspending judgment, weighing alternative viewpoints, and interrogating the complexities of problem situations, as an essential part of democratic living (1916/1966). Such habits of mind constitute an education for social responsibility and are an essential part of civic participation in a democracy.

Despite the drawbacks to the national proclamations by GAISE and NCTM there have been vocal mathematics and statistics educators who have advocated for an integration of critical literacy and statistical literacy. Schield argues that “Numeracy focuses primarily on numbers; statistical literacy focuses more on the words framing the numbers” (2004, p.1). Steen also writes about this interconnectedness between words and numerical information: “Literacy is no longer just a matter of words, sentences and paragraphs, but also of data, measurements, graphs and inferences. . . Numbers count because ideas count” (1997, p. xxvii). Steen and others have argued that students must be skilled interpreters of data texts so that voice, opinion, argument and reasoning become the hallmarks of a literate citizenry. Learning to calculate must be balanced with learning to interpret and critique: “On the one hand is calculation; on the other interpretation. The one reasons *with* numbers to produce an answer; the other reasons *about* numbers to produce an understanding” (Steen, 2007, p.10). Best underscores this point when he asserts that we need “to understand the social construction of numbers more than their calculation” (2004, p.173), e.g. who produced the statistic, why did they produce it, and how did they produce it? Again the emphasis in statistical literacy, as espoused by these mathematicians and statisticians, is not solely on the calculation but also on the language, the context, and the interpretation.

2. Perspectives from Literacy Theory and Pedagogy

2.1 Critical Literacy Theory

Theoretical perspectives from the field of literacy, particularly the area known as critical literacy, further explain what it means to be a critical reader and writer of data-related texts. One of the basic tenets of critical literacy theory is that because all texts are human constructions, they reflect the motives, cultural perspectives, interests, and experiences of the authors (Gee, 1996; Harste, 2003; Janks, 2011). From a critical literacy perspective, being fully literate includes such skills and dispositions as the ability to view texts from multiple perspectives, to analyze the ways a given text privileges a particular point of view, to identify ideas or perspectives that are lost or minimized, and to take social action to address areas of injustice. Since reading and writing are tools of communication across all disciplines, this definition extends to all content areas.

Several educational theorists also discuss the implications of these ideas for instruction. For example, Luke and Freebody (1999) and Vivian Vasquez (2004) assert that critical literacy instruction needs to be an integral part of learning to read. According to Luke and Freebody, effective readers demonstrate four sets of literacy practices. Three of the practices are those that are widely recognized as parts of reading in the elementary school: phonics (letter-sound relationships), meaning (semantics/ vocabulary/ context), and syntax (sentence structure/parts of speech/ grammar). Of particular interest here is the fourth aspect: reader as critic. In this role the reader recognizes the pragmatics or social purposes of a text, i.e. the relationship between the choices authors make (e.g. word choice, format) and the effects on readers' thoughts and actions. Questions that promote this critical stance include, "Whose voice is heard in this text? Whose voices are left out? What might [character who is not heard] say about _____?" (Vasquez, 2010). To Luke and Freebody and others, it is impossible to separate this aspect of reading from the vocabulary, sentence structure and organization of a text. We argue here that it is imperative to focus attention on data-related texts within a critical literacy framework in the earliest grades.

2.2 Pedagogical Principles that Inform Statistical Literacy Instruction

Several pedagogical principles that guide all literacy instruction apply equally well to the development of statistical literacy:

- Reading and writing are related
- New knowledge builds on the familiar
- Reading and writing for real purposes encourages reflection
- Reflection builds understanding

The first is the idea that children become better readers as they write, and, conversely, better writers as they read (National Council of Teachers of English, 2004). In other words, when children read, they learn how authors compose, and, in turn, as they compose, they gain an insider's perspective of how texts operate, and thus develop further background knowledge that helps them read. In the area of statistical literacy, this principle suggests that children need ample opportunities to collect, represent, interpret, and critique their own data texts. Since they are then familiar with the choices that they made (e.g. what gets counted, how data are categorized, what format of a visual display to use), they are able to identify what is minimized, lost, or brought to the forefront in their graphs and data reports.

It is also essential that these experiences with data relate to children's prior experiences and interests. New knowledge builds on the familiar. For example, children's earliest experiences with data should revolve around such topics as learning to tie one's shoe, favorite toys, foods, or pastimes, and school routines such as attendance or lunch counts. Children can also use data to address conflicts that arise, e.g. collecting data about the popularity of different pieces of playground equipment in order to establish rules for their fair use. These kinds of contexts give meaningful purposes to the children's investigations, thus increasing their interest, investment in the process, and ultimately their learning.

Finally, it is important for children to discuss their results and interpretations with their peers so that they gain experience hearing and thinking about different perspectives and points of view. Children should also write about their findings and interpretations; both talking and writing are tools for reflection, and reflection builds insight. Sharing their work with peers and other audiences also encourages children to reflect on the decisions that they make throughout an investigation. As their understanding about data texts deepens with further experiences over time, they gain confidence in critiquing the texts they encounter in published sources.

2. 3 An Instructional Design to Promote Critique

We have developed a heuristic (Appendix A) that teachers can use as a tool for promoting this important critical perspective in their classrooms (Whitin & Whitin, 2011, p. 10). It outlines various features of the data-gathering process such as the social context, the question, definitions, categories, visual representations, sample and conclusions. The accompanying questions are ones that teachers can adapt depending upon the age and experiences of their students, and then use to demonstrate a questioning, probing stance. The questions then have the potential to become a part of the established norms of classroom discourse, and children can begin to internalize these habits of mind. The intent of these questions is to uncover the decisions that authors of a given data text made, imagine alternative possibilities and then analyze the effects of those various scenarios. The classroom examples that we describe next incorporate several of these questions as well as illustrate a variety of instructional strategies that teachers can use to foster this critical orientation toward data texts. These strategies and questions include:

1. Display the same set of data in two different ways. What does each show and not show?

2. Brainstorm alternative ways to pose a question, define a term, and categorize responses. What are the possible effects for each of these alternatives?

3. Aggregate and disaggregate a set of data in several different ways. What information is lost or gained by each categorization?

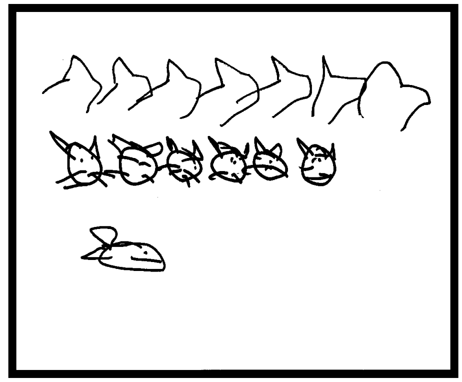
Let us now turn to this first strategy and examine its use in a primary classroom.

3. Classroom Examples of Instructional Strategies

3. 1 Representing Data in More than One Way: Do You Have a Pet?

The following example demonstrates how teachers can lay a foundation for critical thinking with young children by challenging them to represent a set of data in two different ways. If the topic is based on a familiar context, and it is one that children care about, then even young children can show sophisticated, insightful thinking. In this first grade classroom the children were given regular opportunities to collect and represent data about topics that interested them.

In this present example one child decided to canvass her friends about their pets by asking, "Do you have a pet?" (Whitin & Whitin, 2011). She was allowed to represent her information in whatever way made sense to her. She was given a blank piece of paper since lined paper would already predispose her to represent her data in a linear way. Blank paper offers an open-invitation for children to record their peers' responses in their own personal way. The child decided to use silhouettes to represent the pets of her classmates (Figure 1a). When she finished her polling the teacher challenged her to represent this same information in another way. She decided upon the familiar format of a pictograph that she had seen her teacher use several times in the past (Figure 1b).



Figures 1a and 1b: A first grader represents her pet survey data in two different ways. Copyright (2011) From *Learning to read the numbers: Integrating critical literacy and critical numeracy in K-8 classrooms* by David J. Whitin & Phyllis Whitin. Reproduced by permission of Taylor and Francis Group, LLC, a division of Informa plc.

When she shared both her representations with her classmates they noted the many layers of information in her first visual. One child remarked, "You can see who has more than one animal to feed." Others observed that her first representation also showed the kind of pets each person owned, the number of people that she had surveyed, and the total number of each kind of pet. When the children analyzed her second representation they noticed that it was easier to compare each category of animal. However, some layers of information that were included in the first graph were not represented in this second one, such as the number of multiple owners, the kind of pets individual students owned, and the number of people polled.

This discussion highlighted some significant understandings that the children were gaining about data texts. They were learning that there is no one-to-one correspondence between a set of data and its visual referent. There are myriad ways that a set of data can be represented. As authors themselves the children were also realizing that composers of data texts make choices that affect what their audience sees and does not see. Their own analysis of these two graphs demonstrated to them that different representations of the same set of data can reveal some relationships and conceal others.

All of these lessons point to the larger idea that representations of data are human constructs. Authors of data texts, just like any text, have choices about how they represent their information. This insight can empower even young children to examine and interrogate those choices. Having choices means that things could be otherwise. A choice that an author makes represents only one option from an array of possibilities. As young children gain more experience in collecting and representing data, and as they examine the decisions that other authors have made, they begin to realize the power that all authors can wield in constructing arguments and promoting personal points of view. In time this political aspect of authoring texts can become apparent to them: "All the selections are motivated; they are designed to convey particular meanings in particular ways and to have particular effects…They entice us into their way of seeing and understanding the world --- into their versions of reality. Every text is just one set of perspectives on the world" (Janks, 2010, p. 61).

3. 2 Definitions Matter: The Popcorn Experiment

Elementary age children can also develop a skeptical orientation toward data when they interrogate the definitions of words. They soon learn that it is the definitions that determine what gets counted, and so critics must interrogate those definitions if they are to gain a deeper understanding of both the results and the conclusions. To illustrate this questioning stance toward definitions we share an example from a third grade class (Whitin & Whitin, 2011). The children were conducting an experiment to determine which brand of popcorn had the better rate of popped kernels, a generic brand or a name brand (Orville's). They thought the experiment was simple enough. Just pop the kernels from each brand and then count the popped kernels to determine the winner. However, once they began sifting through the two batches of popped kernels to do their counting a major disagreement arose: What counts as being "popped?" Some children argued that the kernel had to be fully popped while others contended that partially popped kernels should also be counted because, as one child argued, "I would eat it!" However, others disagreed: "Not me. I wouldn't eat any of the kernel part." Through their discussion emerged the criterion of edibility in defining the word "popped."

Finally the children decided upon a compromise that stated the kernel had to be popped at least half way to be counted. Of course even this definition had its detractors. Some still argued that they would not eat half popped kernels while others admitted that they would eat kernels that were barely popped. Nevertheless, this definition was the one that the majority of the children agreed upon. After their counting was done they announced that the generic popcorn had the better rate of popping. However, Orville might have challenged these results by claiming that a better criterion would have been counting just the fully popped kernels. This criterion was lost when it was aggregated with some of the partially popped kernels. Orville might have also argued that taste might be a better criterion for comparing brands of popcorn, rather than the number of popped kernels. Imagining how Orville might have viewed the results helps children view the data from a broader perspective and entertain multiple interpretations of the data.

Although all the children never completely agreed on a suitable definition it was important that this issue arose. As they grappled with defining "popped" and then counting the kernels later on, they were learning that there was an inextricable relationship between words and numbers. Often times when a number is attached to a word (such as homeless, unemployment, or school achievement) there is a definition lurking in the background that has determined that number. The children were learning that definitions of terms can expand or narrow what gets counted. They were also learning that being skeptical is an important attitude to hold toward data in science. Although the process of scientific investigation is often portrayed as a clean, linear and rational endeavor, it is in fact a messy process replete with debate, disagreement and often, conflicting results. All of these insights are important ones for children to gain, and they are possible if topics are tied to children's interests. Teachers also play a key role by giving children ownership in solving the problems that inevitably arise when designing experiments and collecting and displaying data. In this way children gain an insider's perspective on the data gathering process and come to understand that all data texts are human constructs that can be debated, questioned, and challenged. They realize that no text is neutral. Any text, including data-infused texts and even scientific texts, is the result of choices that the author of that text had to make along the way. Critics know that it is their responsibility to interrogate those choices so that they might be better able to evaluate the usefulness of that data in making an informed decision.

3.3 Examples from a Grade 5 Interdisciplinary Unit of Study

The following examples illustrate how an interdisciplinary unit of study can provide a meaningful context for several interrelated aspects of a critical orientation toward data-related texts (Whitin & Whitin, 2011). Throughout a school year we worked with children from two fifth-grade classes. In the fall we involved children in several short projects that involved collecting, representing, and interpreting data. We used these projects to give children experience displaying the same data set two ways, and analyzing what graphs "say" or "don't say". The examples we describe here occurred during the winter and early spring, during which time the children investigated cereal advertising on children's television. In this long-term project they collected data about the type and frequency of TV commercials, analyzed the nutritional content of advertised cereals, and polled their schoolmates about their families' cereal purchasing habits. They used the results of their research to compose an informational PowerPoint presentation for their peers and to write letters to government officials, cereal companies, and television networks in which they advocated changes to advertising practices. The project therefore built upon the children's experiences as consumers and culminated in sharing their work with meaningful audiences.

3.3.1 What makes a cereal "Very Good"?

When the fifth graders analyzed the data collected from viewing TV programs they found that a high proportion of ads featured cereals. They were well aware that marketers feature games and prizes as incentives, and they knew that many of the advertised brands are high in sugar content. Through an Internet search we located a Consumer Reports document that ranked cereals marketed to children (Boyles, 2008). Twenty-seven of these cereals were categorized as Very Good, Good, and Fair (the lowest ranking that Consumer Reports uses) based on three criteria: sugar, sodium, and fiber content. The ranking system therefore reflected a complex set of decisions about defining and categorizing data. For example, the investigators established that to be ranked Very Good the cereal must not exceed 9 g sugar or 210 mg of sodium, and that the fiber content had to be at least 2 g. According to this system, then, a cereal such as Rice Krispies that has only 4 g sugar is one of the lowest ranked brands because it has 220 mg sodium and no fiber. We created a table that summarized the information from Boyles' article and supplemented it with additional information from labels on cereal boxes. Figure 2 shows a portion of the table. We distributed this table to the children and asked them for their general observations and analysis.

Cereal	**Sugar**	**Sodium**	**Fiber**	**Rating**
Cheerios	1 g	210 mg	2 g	Very good
Honey Nut Cheerios	9 g	190 mg	2 g	Very good
Kix	3 g	210 mg	3 g	Very good
Frosted Flakes	11 g	140 mg	1 g	Good
Reduced Sugar Frosted Flakes	8 g	180 mg	<1 g	Good
Reese's Puffs	12g	180 mg	1 g	Good
Trix	12 g	190 mg	1 g	Good
Cap'n Crunch	12g	200 mg	1 g	Fair

Figure 2: Selected cereals as ranked by Consumer Reports (Boyles, 2008)

The children's comments showed their growing understanding and appreciation for human decision making in collecting and representing data. Upon initial examination many children were confused that a cereal like Reduced Sugar Frosted Flakes, with 8 g sugar, was rated lower than Honey Nut Cheerios (9 g). Noticing the fiber content for the former as less than 1 g, one girl reasoned, "I guess that's why it's in the Good [rather than Very Good] category. Fiber is good for you and it doesn't have much." Another child raised a question about the Very Good rating for Kix, a cereal that had the maximum level of sodium (210 mg). She commented that this amount "was surprising because Kix is better for you" [according to the rating]. Apparently, Kix's low sugar (3 g) and high fiber (3 g) earned it this rating. The children began to realize that Consumer Reports made some concessions to sodium content in light of the positive nutritional value of fiber.

Analyzing the decisions behind this published report was an eye-opening experience for these youngsters. They were beginning to realize that even the "experts" on the Internet had to make difficult choices in defining the criteria and classifying the cereals. These investigators faced similar kinds of decisions that the children encountered when they defined their terms and categorized data. Just as the children had faced dilemmas establishing clear-cut categories of data that they had gathered, these published authors had struggled with their own definition of "very good" and with the parameters of the categories. The authors of the ranking system had resolved their problem by balancing considerations for sugar, sodium, and fiber. Interestingly, the report even included a statement that "the investigators noted that there was room for improvement in sugar and/or fiber content for most" [of the cereals ranked Good] (Boyles, 2008). This ranking system was a result of many choices, and it was clear that other choices could have been made.

Raising questions about the rankings seemed to give the children confidence to offer alternative choices and thereby challenge these "expert" decisions. Some argued against the range of 1 - 9 g sugar content for the Very Good category, offering such critiques as, "There's a big difference between 1 g and 9 g." One boy who had measured and compared the amount of sugar in various cereals wrote: "Honey Nut Cheerios has 9 g of sugar in each bowl. 1/3 of it is sugar [i.e. or roughly 9 of a 28 g serving] or 33 1/3%. The sugar is not good for you though." Drawing a "bowl" with 1/3 of it marked off as "sugar" convinced him that Consumer Reports had made the category of Very Good too broad.

Other children suggested re-ranking various brands. One wrote, "On the computer there was a report that rated Reese's Puffs [as] Good but I think it's bad because it has too much sugar and sodium.” Another suggested that Cap’n Crunch should be moved from the Fair to Good category because “it has 12 g sugar, 200 mg sodium and 1 g fiber. That’s practically the same as Trix : 12 g sugar, 190 mg sodium and 1 g fiber. That’s not much of a difference, only 10 mg. of sodium,” she argued. Hearing their counter-suggestions indicated to us that these fifth grade children were building a healthy skepticism toward data from authoritative sources.

3.3.2 Critiquing the design of survey questions

In another part of the project, the children designed a survey in order to gather information about the TV viewing experiences and cereal preferences/purchasing habits of their fellow students (Whitin & Whitin, 2011). Second, fourth, and sixth grade children participated in the poll. The fifth graders were committed to gathering accurate data. They had become invested in the topic after learning more about the nutritional content of cereals and about marketing strategies. They suspected that their survey would reveal that cereal advertising impacted the well being of the school population. These considerations influenced the choices they made as they designed the instrument, as well as the deliberations they had about the tabulation, representation and interpretation of their results. In the process they learned that this instrument was not entirely objective, and that there were limits to the conclusions they could draw. An examination of two of the survey questions, discussed here and in the following section, illustrates these ideas.

For one of the questions the children wanted to know the kinds of factors that influenced children’s cereal preferences. From their own experiences the children thought that the major influences were advertised incentives such as cash cards and prizes, taste, and nutrition. As one child noted regarding nutrition, he and his mother talked about “sweet vs. healthy.” They also surmised that younger children might identify toys and games as their strongest reasons to choose a cereal, whereas older children might name nutrition and cash cards. They included all of these as choices in their survey question. To raise their awareness of how sequence and spatial layout might influence the responders, we asked, “How can we arrange the choices so that the children who fill out the survey take time to read all of the choices? Should they be in a list form or spaced across the page? Where might you put the choices that are not prizes (taste, nutrition)?” In this way the definition of “question” encompassed both words and layout. We opened a word document on our laptop and experimented with different alternatives for the arrangement. The children decided upon a version that separated “taste” and “nutrition” as well as the two incentives that they thought clearly targeted younger and older children, “toy” and “cash card:”

What makes you most interested to buy a cereal?

Toy Game Taste

Clothes/school supplies Nutrition Cash Card

With our guidance the children also considered several contextual factors related to socially constructed norms, values, and perceptions of power relationships. We initiated a conversation about the difference between conducting this survey at school rather than in a neighborhood. School is a setting in which high expectations for good behavior and responsible decisions are set. With this idea in mind the fifth graders discussed why the respondents shouldn’t put their names on the survey, commenting, “They might put down what the teacher would want,” or “They wouldn’t want the teacher to know if they circled something that wasn't good." The children also realized that their status as fifth-graders might intensify second and fourth graders' desire to "look like a good kid."

The children themselves raised another concern about the design of the question. They thought that asking their schoolmates to select only one of the choices might create a difficult situation for the respondents. These pollsters wondered, "What if some kids want to circle more than one choice?" "They might feel pressured to choose just one." They therefore revised their question by adding, CIRCLE 1 OR 2. Making all of these decisions about a single survey question reinforced for these children that their current design was only one of many alternatives, and that other choices would yield different results. Their text, like all others, was not neutral. It reflected their interests, experiences, and sociocultural perspectives (Janks, 2010).

Having experienced this composing process, the children were well prepared to identify what their results "didn't say" when they tabulated the results. Since they offered the option of circling one or two choices, the fifth graders did not know if the circled responses indicated a first or second choice. Therefore, even though "taste" yielded the highest number of votes, the children could not be certain that "taste" was the primary reason that students chose their particular brands of cereal. In addition, they could not say with certainty how the respondents defined the word "taste." The fifth graders had discussed among themselves their own taste preferences. Many had admitted that they liked several of the brands identified with high sugar content, noting that the one with the lowest content "tastes like grain." On the other hand, others complained that younger siblings chose cereals that were "too sweet." The children also realized that the broad category of "games" prevented them from drawing any conclusions about whether there was a correlation between the age of a child and the kind of games they preferred. They had expected that only younger children would favor toys or games as reasons to choose cereals. However, as they tallied the results, they realized that there were other games, e.g. "brain games," that appeal to older children. Through these experiences the children better understood that there were important differences between results and conclusions.

3.3.3 Exploring how results are displayed and reported

Another survey question pertained to the respondents' role in their families' cereal purchasing habits (Whitin & Whitin, 2011). In their reading these fifth graders had learned that marketers know that children wield power in deciding what foods their families buy. For this reason marketers design commercials specifically targeted toward children. The fifth graders now wanted to see if their survey data would give positive evidence for their hypothesis that "advertisers get their way at our school." Based on their own experiences, they wrote this question:

Who in your family picks out the cereals?

Me   Adult   Brother/sister   Me and an adult

In this case, the most important lessons arose when the children tabulated and represented the results. Through this experience the children learned that authors can choose among options for aggregating or disaggregating categories of data to promote a particular point of view. The 60 surveys yielded these results:

28 Me and an adult
15 Me
9 Brother/sister
8 Adult

Two children took responsibility for representing the data. David guided them as they each created a pie chart (Figure 3). They expressed the findings as fractions (first in relation to 60, e.g. 28/60, then rounded to simpler fractions, e.g. ½) and then estimated them as percentages. They noted these percentages on the chart: 48% Me and an Adult, 25% Me, 14% Brother/Sister, and 13%, Adult. Together they reviewed their work before the girls wrote individual reports about their findings. David asked, "How many responses involved kids in some way?" They replied that all of the categories included children's role except "adult", the category with only 8 tallies and representing a mere 13% of the responses. David pointed out the option of aggregating the three child-related categories into one, thereby showing that 87% of families involve children in purchasing decisions, while 13% of families do not. The girls realized that their using this aggregated total of 87% would strengthen their argument that marketers were indeed "getting their way at our school." The children felt that the advertisers were achieving their goal by using children at their school to influence families' purchasing habits.

In hindsight it would have also been beneficial to discuss with the children a different way to aggregate some of the categories that would not have bolstered their argument as well. For instance, if they had aggregated the two categories that mentioned adults ("Adults" of 13% and "Me and an Adult" of 48%) they would have found that 61% of households involve adults in the decision making about cereal purchases, and only 39% of families give children the sole power in deciding which cereals to buy. This second categorization clearly minimizes the role that children play in such family decision-making. The point here is that showing this alternative way to aggregate results demonstrates again the power that composers have in framing an issue with their particular point of view in mind.

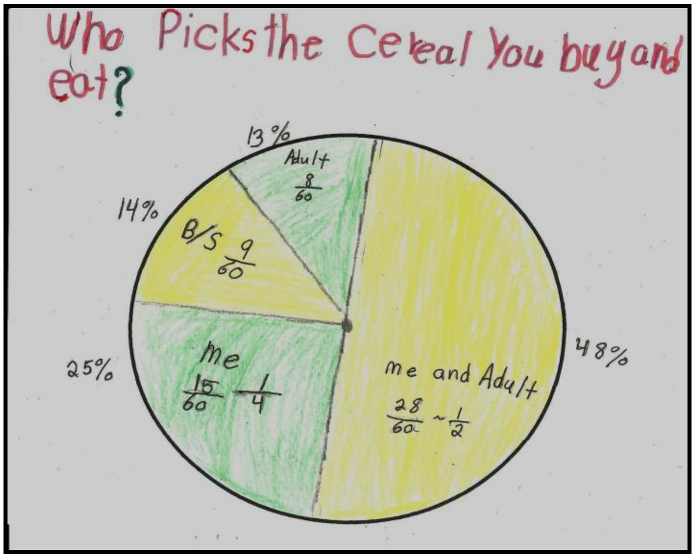


Figure 3: A pie chart representing survey results to the question, "Who in your family picks out the cereals?"

Although the girls did not revise their pie charts, they did include the information about aggregated categories in their written reports. They also included it in an informational PowerPoint that they created to present to their fellow fifth grade classes (Whitin & Whitin, 2011). Instead of representing the results as a pie chart, they created a way to feature the aggregated data while preserving the audience's access to the disaggregated categories (Figure 4 shows a rough draft of their slide). In large numerals and centered at the top of the page, they wrote the aggregated figure that was central to their argument, "87% of kids have a say-so on what cereal they eat." Below, they placed the second category of 13% ("parents have all the say-so on what cereal their children eat"). Since they felt that it would be unfair to their audience to omit the disaggregated data completely, they did include it but gave it secondary importance by using smaller lettering and placing it in the four corners of the page. They knew that their inclusion of the disaggregated data would allow readers to explicitly see how these aggregated totals were determined. We suspect it was their growing awareness of the power and control they had in shaping the data in their own way that influenced them to share the disaggregated totals in this honest and open manner.

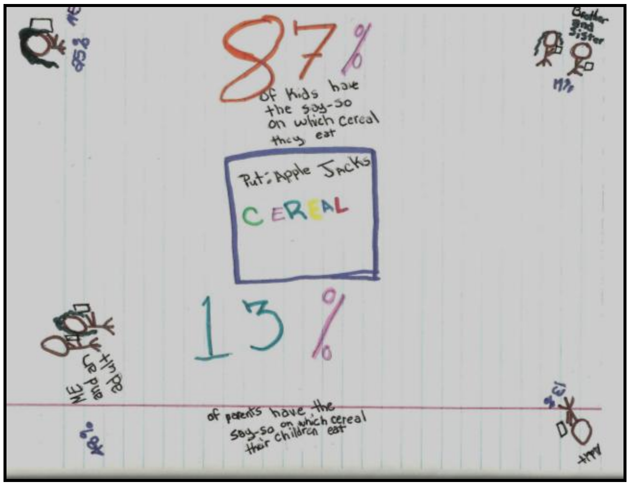


Figure 4: The children featured aggregated data on the draft of their PowerPoint slide to better present their argument that their schoolmates influenced their families' cereal purchasing decisions.

This experience was a valuable way for the children to gain perspective about the effects of aggregating or disaggregating data in different ways. It was important that they had a meaningful purpose and audience for presenting their results. They and their classmates had a drive to make sense of their data because they saw how it impacted their lives and those of their families and schoolmates. They tried to present their findings in a way that was clear to their audience. Creating the PowerPoint in particular gave them insight into the ways that people can use words, numbers, and visuals together to present a particular point of view.

4. Concluding Thoughts

Statistical literacy, with its important emphasis on developing a critical disposition toward data texts, is an essential part of 21st century literacy. The purpose of this article has been to show that it is possible to foster and develop this skeptical habit of mind in elementary school. Children can demonstrate this important disposition when the data are connected to a familiar context. Teachers play a key role in supporting this critical orientation by posing questions that invite children to interrogate their own authoring decisions as well as the decisions of others. Teachers' questions can help children analyze how to pose a question, define a term, categorize a response, compare and contrast visual representations of the same data, distinguish between results and conclusions, and expose the criteria of a ranking system. A critical disposition is also deepened when children are both readers and writers of data texts, and when they are encouraged to question data texts across all subject areas. The data that the children interrogated in this article reflected social statistics (pet survey), science (popcorn, cereals), health, and economics (cereals). Being critical also involves an understanding that since all texts are partial they have limitations. In addition "partial" implies that any given text represents only one set of choices. By interrogating these limits of numerical information children can better judge the usefulness of that information for their own decision making. Such probing and questioning is the right and responsibility of citizens living in a democratic society.

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Appendix A

Questions to Support a Critical Orientation toward Statistics		
Feature	**Critic's Perspective**	**Questions to Consider**
1. The Social Context	The researcher's motives, the setting, and the status of participants influence all aspects of the process.	What is your purpose for collecting this information? Who is you audience? How are you collecting this information?
2. The Question	The way a question is posed influences the kinds of responses one receives.	How did you ask your question? Why did you ask it in that way? How might this language have influenced the responses you received? What groups of people did your question privilege? silence? How else might the question have been worded?
3. The Definitions	Broad or narrow definitions determine what gets counted. The choice of words reflects the intentions of the author.	How did you define this word? Why did you define it this way rather than another way? What groups of people did your definition or choice of words privilege? silence?
4. The Categories	Data can be aggregated or disaggregated to serve one's purposes.	How were the categories decided upon? What happened to responses that did not fit into these categories? In what other ways might you categorize these data? What information is lost by using these categories?
5. The Visual Representation	Displays can reveal and conceal certain layers of information.	Why did you decide to show your information in this way? What information is concealed/ revealed by this form of representation? Who benefits from representing the data in this way? How else could you have displayed your data?
6. The Sample	The knowledge, background, interests and biases of the sampled population influence their responses.	Who did you ask? How informed was the sampled population about this topic? What might have happened if you had asked a different group of people?
7. The Conclusions	Conclusions are based upon the assumptions of the researchers.	How are your results different from your conclusions? What conclusions can't we make? How might your choice of a mathematical concept (ratio, average) influence your audience's thinking?