

Chapter 13

Critical Understanding of Civic Statistics: Engaging with Important Contexts, Texts, and Opinion Questions



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Abstract This chapter aims to support teachers and lecturers interested in developing students' statistical literacy in general and critical understanding of Civic Statistics in particular. The chapter provides practical advice regarding task design and development of activities that encourage critical analysis of statistical texts (such as in the news media or publications of official statistics agencies). Key topics include: analysis of the nature of 'context knowledge' and what are 'meaningful and important' contexts that are worthy of attention when teaching for understanding of Civic Statistics; ways to bring 'meaningful and important' contexts and texts about them (e.g., from newspapers or digital media) into the classroom and to make sure students understand them; ideas about question-posing and designing suitable tasks about these meaningful and important contexts, in particular how to shape 'opinion questions' that can elicit students' critical reading, reflective thinking, and communication of thoughtful opinions; and ideas about the dispositions and habits of mind (e.g., critical stance, ability to ask 'worry questions') and skills (e.g., reading comprehension, critical interpretation) we want students to internalized and be able to activate when engaging statistical messages. Based on the guidelines and examples regarding these topics, the chapter discusses implications and recommendations for curriculum design and for teaching and teachers working both at the high-school, college, and adult education contexts, in mathematics education, statistics and data science education, and related STEM disciplines.

Keywords Statistical literacy · Contextualization · Critical numeracy · Data literacy · Task design · Official statistics

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13.1 Introduction

This chapter aims to help educators who want to develop their students' knowledge and critical understanding of *Civic Statistics* in diverse teaching contexts, e.g., a high-school class, a college-level course, or an adult education program. As Chap. 2 of this book argues, learners need to develop their ability to engage with Civic Statistics that are generated or collected in real world contexts, and that pertain to 'burning topics' (i.e., the areas of Civic Statistics) which matter to modern societies because they affect social or economic well-being (Engel et al. 2016). Developing the ability to engage with and critically understand Civic Statistics requires attention to numerous facets and tools, and to knowledge bases and dispositions, which were discussed in Chap. 3, in connection with a conceptual framework developed by the ProCivicStat project (Nicholson et al. 2017). The richness of the demands on adults in terms of critical understanding of statistical and mathematical products in media items was recently documented by Gal & Geiger (2022), who analysed a large purposive sample of 300 diverse media items related to the COVID-19 (Coronavirus) pandemic, selected from digital news sources based in four countries. Gal & Geiger's (2022) results provide empirical support for the conceptual framework proposed by ProCivicStat Partners (2018) regarding the capabilities needed for engaging with Civic Statistics topics.

Based on the foundations in Part I of this book, the present chapter focuses on educational issues associated with two fundamental knowledge bases described in Chap. 3: 'Contextual Civic Knowledge' and 'Critical Evaluation and Reflection'. Contextual knowledge is fundamental for the development of understanding of Civic Statistics, since learners (and citizens) need to be able to read and reflect about statistics 'in context', i.e., understand the social or economic importance of any statistics they engage with, and its implications for society. 'Critical evaluation and reflection' is fundamental because it involves ways of thinking about, interrogating, being skeptic, or asking 'worry questions' about statistical findings and statistics-based or quantitative claims which are common in public life (Gal, 2002; West & Bergstrom, 2020). Both of these knowledge bases can challenge many teachers because they are not normally included, or only superficially addressed, in standard instruction and in textbooks related to statistics which are used in mathematics, science, or statistics education.

As a brief scholarly background, we note that attention to context knowledge and to critical evaluation has been a part of past discussions regarding statistical and mathematical literacy (e.g., Budgett & Rose, 2017; Haack, 1979; Watson, 2013), as well as (adult) numeracy (Gal et al., 2020) and data and media literacy. One often-quoted definition (Gal, 2002) views statistical literacy as referring broadly to two interrelated components:

...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 their ability to *discuss or communicate* their reactions to such statistical information, such as their understanding of the meaning of the information, their opinions

Table 13.1 Three key questions about context knowledge and critical evaluation

| Questions/topics | Brief rationale |
|---|--|
| 1. What are ‘meaningful and important’ contexts, and why do they matter for Civic Statistics? | Such contexts are mentioned in Chaps. 2 and 3 and are discussed in detail here, because they underlie the generation of Civic Statistics and their interpretation |
| 2. How do we bring ‘meaningful and important’ contexts into the classroom? (The answer: use meaningful texts!) | Texts are at focus for two reasons: They are the key source through which learners can be introduced to information about key social and economic issues or dilemmas central to Civic Statistics, and because texts are the prime medium for communicating statistical findings and messages (i.e., telling data stories) to citizens and decision makers |
| 3. What critical or reflective questions about meaningful and important contexts in Civic Statistics are worth posing in class? | Educators need to know how to design sequences of questions that take students from literal reading of simple texts to the expression of opinions with reasoned justifications about complex texts. Teachers need a repertoire of critical questions about Civic Statistics that students can then internalise - and hopefully apply in their future life as empowered adults and citizens |

about the implications of this information, or their concerns regarding the acceptability of given conclusions. [page 2]

Defined in this way, statistical literacy is not a watered-down version or simple subset of formal statistics, but a stand-alone complex competency which is related to adult numeracy (Gal, 1997; Gal et al., 2020) and mathematical literacy (Kilpatrick, 2001), but goes beyond them, since statistics and risk include many unique issues (see Chap. 3). Notions of contextualization and of critical questioning are subsumed in these and other sources referenced in all chapters in Part I of this book, hence will not be repeated here.

With the above in mind, the remainder of this chapter focuses on three broad questions listed in Table 13.1 together with their underlying rationale. Please study Table 13.1 as it motivates this entire chapter, which aims to provide both a scholarly background and practical advice for educators who seek ideas on how to develop and implement in their classrooms critical understanding of context-rich statistics and data-based stories about issues of importance to society.

Accordingly, the chapter is organized in nine sections. Following this introduction, Sect. 13.2 elaborates on the key notion of ‘context knowledge’ and Sect. 13.3 on the first issue listed in Table 13.1, i.e., the nature of meaningful and important contexts. Section 13.4 considers the second issue listed in Table 13.1, i.e., ways to bring such contexts into the classroom. Sections 13.5–13.7 discuss the third issue of question posing, and provide guidelines and illustrations for creating ‘opinion questions’ that can elicit students’ reflection and expression of opinions when teaching about Civic Statistics. Section 13.8 examines additional critical questions

which students should internalise and skills that they should activate when engaging with Civic Statistics and statistics-based messages. Finally, Sect. 13.9 summarizes key messages and poses some questions to support reflections about pedagogy related to Civic Statistics.

13.2 The Centrality of ‘Context’ for Statistical Literacy and for Understanding Civic Statistics in Particular

‘Context’ seems to be a simple idea. After all, we all live our lives in context, not in a vacuum. And as educators, we hope that what we have taught our learners will help them to function effectively as engaged and empowered adults and citizens in multiple life contexts. However, within the classroom or lecture hall, ‘context’ is far from being a simple notion. This is because ‘context’ is not automatically present in the classroom—we need to bring it in. But on this, there is a difference between mathematics education (which is where much of statistics education happens in schools) and statistics education (which covers the school level as well as tertiary levels and many other teaching contexts, but at the tertiary level occurs mainly on its own, not under mathematics education).

In mathematics education (at the k-12 and adult levels) there are many discussions about contexts, authenticity, or realism of tasks and problems, and debates about the extent to which mathematics educators should worry about or relate to contexts as part of either teaching/learning or assessment processes. A succinct review of various views on contexts and contextualization can be found in Greatorex (2014). For example, as du Feu (2001) argues, there are five types of contexts (or lack thereof) for tasks and activities used in the mathematics classroom: *context-free*, *real*, *cleaned*, *parable* (fictitious but possibly real), and *contrived* (invented to drive a mathematical problem, but usually not realistic). It follows that when learning mathematics, a real context is not always seen as needed, and sometimes is even perceived as a distraction that hurts the learning of abstract ideas in mathematics.

In contrast, when teaching statistics, *context is supposed to be a foundation of all activities*. After all, the history of statistics shows that the discipline was invented in large part to serve practical needs of states and to enable administrators to understand the demographics and living conditions of their citizens and economies. Cobb and Moore (1997) have argued that statistics are ‘numbers in context’, and that hence, in statistics, context is the source of meaning and basis for application of statistical procedures and for the interpretation of obtained results.

Let us now reconnect with the statistical literacy point of view, which emphasizes the importance of developing citizenship-related competencies. From this perspective, it can be argued that our overarching goal in teaching statistics is that when students graduate, they are both able *and* willing to engage effectively and make sense of the statistics and statistical messages that flow to them as citizens or smart consumers of statistical messages. If so, it is critical to ask—how are the

contexts in which real-world ‘Civic Statistics’—those related to social, economic, or environmental life topics—chosen by teachers and brought into the statistics classroom?

Questioning the place of ‘context’ in statistics education is where I believe we face a problem, or misunderstanding. There are many calls to improve conceptual understanding of ‘big ideas’ in statistics and to put less emphasis on procedural knowledge (Chance & Rossman, 2001; Cobb, 2007; Malone et al., 2012; Ograjenšek & Gal, 2016). The *Guidelines for Assessment and Instruction in Statistics Education* (GAISE, 2016) emphasize in particular the importance of using ‘real data’ in the classroom, and there are claims that this can lead to the development of statistical literacy (Schield, 2016). However, there is a big difference between using ‘real’ *data* and linking instruction to *meaningful and important contexts*. What matters is *not* the data per se, but the *answers and insights* we seek in the data (see also Watson, 2000).

It follows that the context (and the ‘need to know’ of different stakeholders) should be *the motivator* for teaching anything about statistics. After all, regular data are collected *because* somebody out there in the real world has specific information needs and specific questions for which they seek answers. Context is central to Civic Statistics—as it directly connects with ‘*meaning for society and policy*’, i.e., the most important facet (facet 1) in the conceptual model (see Chap. 3, Fig. 3.1).

13.3 About Meaningful and Important Contexts

Section 13.2 argued that ‘context’ is a fundamental aspect of Civic Statistics. A question then emerges: What are ‘*meaningful and important*’ contexts, worthy of attention when teaching for statistical literacy in general and understanding of Civic Statistics in particular? This chapter proposes two conditions in this regard. First, *the context should be authentic*, i.e. naturally occurring in the outside world, not contrived or fictitious. Thus, if teachers conduct a local survey (or create fictitious data) simply so students have data to work on—e.g., by eliciting students’ political opinions, body measurements, career plans, etc.—the data would be ‘real’, i.e., pertain to a phenomenon in the world which can be described statistically, but this does not serve as an authentic meaningful and authentic *Civic* context, as explained below.

The second condition is that *the context should invoke a genuine ‘need to know’*, i.e., *be of interest to an outside actor or stakeholder who operates in the public sphere (broadly viewed)*. Key examples of such actors are: politicians; policy-makers and managers in a government ministry (department), a public agency or a business organization; leaders or activists in a community-based or non-profit organization; or concerned and empowered citizens who want to monitor processes in their country or region, and perhaps consider some action. The notion of ‘Need to know’ has been promoted by Ograjenšek and Gal (2016), who argue that a critical challenge in statistics education involves issues of students’ acceptance of *purpose*

and of motivation for the whole activity of generating and interpreting a statistical message or data.

As explained earlier and in Chap. 2, Civic Statistics may involve contexts related to diverse topics such as health, demographics, employment, wages, migration, crime, poverty, access to services, education, human rights, public expenditures, pollution and ‘green’ topics. Such topics are seen as ‘burning issues’ because they affect social and economic progress, and impact upon the well-being of citizens and communities. A potent example is the context of the recent COVID-19 (Coronavirus) pandemic, which combined many of the separate topics listed above.

In combination, the two conditions described in this section aim to maximize students’ sense of relevance of the context to their current or future lives as adults, and improve the motivation and interest both of teachers and students. Hence, Civic Statistics contexts should be chosen which are meaningful and important in the sense that they are at the focus of public and political dialogue, of much interest to policy setting and to decision-makers at the national, regional, and local or community levels, and often discussed in the media.

13.4 How Do We Bring Meaningful Contexts and Statistics About Them into the Classroom?

As explained above, there are many meaningful and important contexts. Hence, teachers have much freedom to choose resources and topics in order to fit their and their students’ interests and capabilities. *Please stop now and reflect on Thinking exercise #1:*

Thinking Exercise/Activity #1: What ‘Teaching Resources’ Are Suitable for Teaching About Civic Statistics?

In particular, focus your thinking on what *information sources* or materials can drive (or motivate) students’ thinking and conversations around the ‘need to know’ of actors in real-world contexts.

Good datasets are essential for learning many statistical ideas. Yet, citizens, or social actors or decision makers, seldom see a raw dataset or need to analyze it by themselves (even though this is often possible, in the era of open data). Usually, citizens and decision makers alike are mostly *consumers* of statistical messages. The raw data, often, have already been analyzed by official statistics producers or by the media. It follows that using datasets, and asking students to analyze raw data may *not* be the preferred way to introduce and develop understanding of Civic Statistics. Students should not spend too much time on the mechanics of number-crunching. Instead, our goal is to develop students’ understanding of the meaning of statistics that are reported to the public, and their ability to critically analyze as well as communicate about socially meaningful questions, relying on data-based arguments.

The goal described requires that we consider two questions:

1. *How are statistics reported to the general public?* Our answer: *mainly via text-based messages*, either written or spoken.
2. *Where can you find such text-based messages?* Our answer: There are multiple places or channels where statistical texts (written or spoken) are communicated to the public, such as:
 - (a) Articles in the print and digital media
 - (b) Press releases, reports, and other products of official statistics producers (these can be found on the websites official statistics agencies)
 - (c) TV programs and websites of news channels (e.g., news reports, or interviews with experts or public officials). Copies of past programs can often be retrieved from the websites of such organizations, and some of them are uploaded to YouTube and other video websites
 - (d) Posts on social media such as Facebook or Twitter (nowadays, most news organizations as well as official statistics agencies have official channels on social networks)
 - (e) Blogs (written) and Podcasts (audio recordings) by commentators and social activists who address a range of civic issues

Materials from any of the types of channels listed above can be useful resources that students should learn to comprehend, analyze, and reason about—see subsequent sections for details. *Authentic sources*—whether *written texts* (as in an article or report) or *spoken texts* (as in a TV news broadcast, or an interview with a public figure or expert)—are the foundational elements which need to be brought into the classroom to enable learners to directly engage with real-world messages involving statistics and quantitative ideas about important contexts.

Presenting students with *authentic* texts (printed or spoken) from such resources carries a great advantage for teachers, for two reasons: the text eliminates or reduces the burden of explaining the social or economic context, and hyperlinks (clickable links) inside digital texts can point to original data sources such as reports from statistics producers or public bodies, or to additional data or even datasets and associated metadata (i.e., definitions of variables, data collection or sampling methods, etc.). And, as will be explained later, authentic texts can provide great opportunities for *question-posing* and designing instructional tasks.

It is further important to emphasize that the messages that teachers or students will find in channels such as those listed above (written or spoken) will contain mainly or only *texts*, i.e., most statistical ideas, findings, or projections, will be conveyed via words, or numbers embedded in words, not via graphical elements. Of course, some visual displays (e.g., infographics, tables, graphs, charts or dynamic visualizations) may accompany the text, but such displays are seldom the core of the statistical messages that the public encounters. The context and the societal issues which motivate the data will not be clear to students without *reading* or *listening*. If students need to get further background information about the civic issue involved, again, they will have to access and comprehend more text (e.g., on Wikipedia). Thus,

text comprehension and *critical reading skills* are essential for understanding Civic Statistics.

13.5 Worthy Tasks and ‘Opinion Questions’ for Developing Critical Understanding of Civic Statistics

This section, and subsequent ones, build on the ideas in Sects. 13.2–13.4, and discuss principles that can guide the design of learning tasks related to contexts and critical understanding of Civic Statistics, offering some examples. To start, assume that you found useful textual sources regarding meaningful and important contexts which discuss Civic Statistics about topics that you or your students may care about. Now you face two different issues:

- What questions should *you* ask your students, or what tasks would *you* assign to your students, about the resource/article you found, in order to develop (or assess) their statistical literacy and understanding of Civic Statistics?
- What questions would you like *your students* to pose to the author/source of the article, or about articles or graphical displays they encounter in real-life? And what mindset or attitudes would you like *your students* to develop and take away from the instructional activities you designed for them?

This section seemingly focuses only on the first challenge listed above, which involves teaching-related issues, as this is the teacher’s playing field. But, in fact, we aim to address the second challenge, because this is the goal of your educational work. This section thus focuses on *question-posing* and *task design*, which are a part of the art of teaching. The terms ‘question’ or ‘task’ should be taken broadly, to encompass the diverse queries, problems, projects and assignments given to students, whether in class or as homework.

Ainley et al. (2015) have argued for the use of tasks that have two characteristics, i.e., questions that have a clear *purpose* and that present an *engaging challenge* for the learners, whether or not they refer to a real-world application. More recently, Arnold and Franklin (2021) have expanded to four types of questions associated with the ‘statistical problem-solving cycle’ and differentiate between Interrogative questions, Investigative questions, Survey or data collection questions, and Analysis questions. However, this may be necessary but certainly is *not* sufficient, when dealing with Civic Statistics. After all, the statistical problem-solving cycle is usually not evident or fully relevant when dealing with Civic Statistics. This is in part because many Civic Statistics are collected on an ongoing basis or as part of a prolonged public process (i.e., for monitoring changes in key indicators related to social and economic phenomena as explained in Chaps. 2 and 3), not as part of a shorter (or one-shot) efforts, as are many regular surveys or empirical studies of a more modest scale which tend to be emphasized in introductory statistics classes.

Table 13.2 Five heuristics for designing opinion questions about Civic Statistics

| Heuristic: Does the question or task ... |
|---|
| 1. ... have an authentic context |
| 2. ... reflect a possible genuine ‘need to know’ of a stakeholder in the given civic context, or be of some service to such an actor |
| 3. ... <i>not</i> provide specific hints as to where in the text, table or graph to look, or what data or statistics to consider or use |
| 4. ... call for a <i>judgment</i> or <i>opinion</i> (not a computed response) that connects with the given civic context |
| 5. ... make it clear to students that they will have to <i>explain</i> and <i>justify</i> any opinion they present, and be alert to the need to reflect on all the information presented, before responding |

Going beyond the Ainley et al. (2015) and Arnold and Franklin (2021) ideas, Table 13.2 presents a broader set of expectations or heuristics for designing a broader type of *opinion questions*, which are tasks that can encourage students’ *reflection* and expression of (*possibly critical*) *opinions* regarding Civic Statistics and their *societal or organizational implications*. (These heuristics are elaborated in Sect. 13.6 below):

Before explaining the five heuristics in Table 13.2, let us first discuss the notion of ‘opinions’. A key idea presented in this chapter, and earlier in Part I of this book, is that students should engage directly with the societal meaning or implications of the statistics and data they encounter. This implies that students have to be exposed to the interchanges and paths between *facts* about Civic Statistics (i.e., statistics or findings or data-based arguments or texts with statistical messages) and *opinions, deductions, and recommendations for action* about Civic Statistics (either ones that they will generate, or that actors in the public sphere communicate via various channels or texts).

Dealing with students’ *opinions* may seem a novel idea because opinions are not usually part of instruction about mathematical subjects—though they are part of many other educational subjects! After all, opinions encountered in the real world may or may not be fully based on facts, and may be influenced by value judgments and subjective views. Further, opinions on complex subjects such as civic topics probably cannot be always classified as ‘right’ or ‘wrong’, and may have various degrees of reasonableness and logical consistency.

In Civic Statistics, dealing with opinions in addition to facts is essential and inevitable. Fred Mosteller, a renowned statistician, said, “Policy implies politics, and politics implies controversy, and the same data that some people use to support a policy are used by others to oppose it” (cited in Moore, 1998, p. 1255). If we want to prepare our students to engage as citizens with burning civic topics, they should be comfortable to generate fact-based opinions but also be able to think critically and consider the evidential basis for their own and others’ opinions. This is especially important if a secondary goal is to understand the use (and misuse) of statistics in the civic sphere in the twenty-first century, where invented ‘evidence’ and biased use of data are common.

With the above in mind, Sect. 13.6 below discusses heuristics for the design of questions and tasks that can generate *opinions* about Civic Statistics topics. It is followed by an annotated example (Sect. 13.7), and a discussion of more types of critical ‘worry questions’ about statistical messages in general (Sect. 13.8).

13.6 More About Heuristics for Designing Opinion Questions

Table 13.2 presented five general heuristics for the design of tasks that can elicit open-ended opinions related to civic contexts. A brief format was used, so it is easy to employ the five heuristics as a check-list to evaluate the appropriateness of tasks and questions being considered for use in class. These heuristics are based in part on Gal (1998) and earlier sources, and the first two also based on Ograjenšek and Gal (2016).

1. Questions posed to students who learn Civic Statistics should emerge from or relate to *authentic contexts*, i.e., should not be ‘contrived’ or ‘fictitious’ or ‘cleaned’.
2. The context and the questions about it should connect with or reflect a genuine ‘*need to know*’. That is, students should be presented with questions or tasks which seek an answer that *can be of some service to a stakeholder in the given civic context*, i.e., a policy-maker, public official, manager, activist, or any other actor operating within or interested in the given context.
3. A question or task should not provide specific hints as to where in the text, table or graph the student should look, or what data or statistics to consider or use. The idea is that the student will have to decide what parts of the text and inherent displays to examine, and how different aspects of the text, or data points in a graph or display, relate to each other.
4. A question or task should be phrased so (a) students realize that a *judgment* or *opinion* is called for, rather than a precise ‘mathematical’ or computed response in the form of a specific number, and (b) that a connection must be made between the opinion and the given authentic civic context.
5. An ‘opinion’ question or task should be phrased so students realize that they will be asked to *explain* and *justify* any opinion they present, and alert them to the need to examine all the information presented and *reflect* on it before responding, in order to formulate a reasoned opinion.

Rationale The five heuristics can be explained in several ways:

- We want students to think about the meaning and interpretation of any statistics within the social context; use their reasoning to examine the logic and support from data for any arguments presented in the text; reflect on causal factors,

correlates or covariants or confounders, and alternative interpretations for the findings or data being discussed; and consider to what extent the implications or consequences of the findings being discussed appear sensible

- We want students to not immediately look only for formal statistical terms in the text but realize that many statistical ideas may be expressed in words in various ways. For example, the statistical idea of a ‘correlation’ can be expressed by many words or phrases, such as association, link, relationship, co-occurrence, influence, and many others
- We want students to be sensitive and open to ambiguities, inconsistencies, or improper uses of wording in what the text or statistics portray (e.g., does ‘influence’ imply that data really shows that there is a causal relationship between the variables? or that the writer/speaker just chose a word without thinking deeply about its statistical implications)

Of course, heuristics are just general guidelines and can be used in a flexible way. That said, opinion questions whose designs are based on these general heuristics can be powerful tools in connecting generic statistical content to civic contexts, as well as helping to develop students’ ability to critically interpret Civic Statistics. *The most important heuristics are the first two:* Unless students are presented with a reasonably realistic context and a reasonable ‘need to know’, they may simply treat the question as a mathematical puzzle, not as an intellectual challenge. For Civic Statistics, we want students to bring into the task the full power of their knowledge about life and society, and their reasoning skills, and to be aware of, and be able to articulate, the assumptions that they have made and rely on as part of their reasoning. *Hence, please stop now and reflect on Thinking exercise #2:*

Thinking Exercise/Activity #2: How Do We Apply the Heuristics Summarized in Table 13.2 for Designing a Task About a Civic Issue?

Please design a task or a set of questions that can generate opinions and reflections about one of the topics described below. Make sure to apply the five heuristics explained above and listed in Table 13.2.

Topic 1—Health inequality: During the COVID-19 (Coronavirus) pandemic, in some countries, people from certain backgrounds or who live in certain communities (e.g., people from certain minority or social backgrounds, or who are in poverty), had quite different (usually higher) rates of infection or mortality and (lower) willingness to vaccinate. This led to articles and TV programs involving discussions and debates (with experts, public officials, politicians, or journalists), regarding the factors that cause such differences in rates, their implications in terms of equality and social justice, and their ramifications for social policy. So an important question is, in simple words: what should a country do about these differences? what investments or changes are needed? *Design an opinion question as explained above,*

(continued)

**Thinking Exercise/Activity #2: How Do We Apply the Heuristics
Summarized in Table 13.2 for Designing a Task About a Civic Issue?**

(continued)

that pertains to this topic and requires the use of public reports or media articles about this issue.

Topic 2—Economic and social inequality: Read the Wikipedia article about ‘Gender pay gap’, which discusses salary (Wage) inequality among men and women, which was introduced as Example 2 in Chap. 3. This page exists in multiple languages. *Design an opinion question as explained above, that pertains to this topic and requires the use of public reports or media articles about this issue.* (Note: many countries publish annual data on this issue, so perhaps you can find local publications on this topic.).

Designing a task or opinion questions about differences between social groups (in this case, in infection or mortality rates, or economic outcomes of labor) is challenging, because of the many possible covariates or intervening variables, such as poverty or economic conditions, social norms, religious practices, age profiles, etc. Further, deeper issues need to be examined, such as whether people from different backgrounds or communities have equal access to healthcare, proper nutrition, living conditions, employment opportunities, and so forth. All this requires that students reflect on many factors and processes in the real world. (More ideas regarding the statistical reporting about the COVID-19 pandemic, and problems with group comparisons, can be found in Ancker, 2020; Ridgway, 2021; and Gal & Geiger, 2022).

However, we need to be careful because a social situation or civic context may not be equally familiar to all students, and they may have different levels of world knowledge or make different assumptions about it. This may cause different students to come up with different opinions based on the same source, and in fact can motivate rich discourse in the classroom. Hence, students’ ideas and thinking processes about text interpretation, data analysis and interpretation can be revealed through follow-up questioning (in class), and the design of the task should make sure the students justify their opinions in effective ways. Nonetheless, such questions are both *feasible* (i.e., students can explore them by using published reports and articles, not by analyzing raw data) and *address meaning for society* (e.g., students can connect the statistics with and discuss implications for social policy).

13.7 An Example for a Task Involving Opinion Questions

Question-posing when developing statistical literacy about meaningful and important societal issues raises dilemmas and requires instructional decisions. To illustrate some of them, we now turn to examine in detail a single task, which also helps to

highlight the differences between different kinds of questions that can be posed in class, and provides some additional scholarly background. The task described below is based on Gal and Trostianitser (2016), and involves understanding a seemingly simple data table showing *population projections* for two subgroups in a society. (Such a table in fact is seldom encountered by citizens learners ‘as is’, but is instead embedded in text, as in a newspaper article which discusses new population projections based on a press release of an official statistics agency).

As a brief background, many scholars have examined issues regarding reading and interpreting information in tables and graphs, given their key role in statistics. Curcio’s (1987) well known framework has discussed three stages in graph comprehension, i.e., reading the data, reading between the data, and reading beyond the data. Friel et al. (2001) have outlined six related cognitive processes in this regard: reading, describing, interpreting, analysing, predicting and extrapolating data. Building on these and other sources, Kemp and Kisanne (2010) offered a five-step framework to guide class discussions:

1. GETTING STARTED: mediating the task to the learners, providing context.
2. WHAT do the numbers mean?
3. HOW do they change or differ (e.g., across subpopulations, or different years)?
4. WHERE are the differences or relationships?
5. WHY do the numbers change (or differ when comparing different groups or timepoints)?

Gal and Trostianitser (2016) have argued for the need to extend the five-step framework introduced by Kemp and Kisanne (2010; see also Prodromou, 2015) by adding a sixth step with questions about the *actual societal meaning or civic implications of the data*, as illustrated in Fig. 13.1. The rationale for adding such a step, in line with Chaps. 2 and 3 of this book, is that there is a need to enhance the linkage with the civic context, as a way to address questions of purpose and motivation when using data or products of official statistics agencies that involve statistics about society.

Figure 13.1 shows a real task given to my students in a first-year college course ‘Introduction to Human Services’ in a Department focused on preparing students to manage service operations in organizations in the public and private sectors in Israel, which is a country with much ethnic, religious, and social diversity. A key feature of the task was that it was presented as a *management simulation* related to understanding client diversity. Thus, students were not ‘doing statistics’ but had to operate in a tangible context in which they can be a real actor, not a passive or disinterested observer who was just given some data.

The data table in Fig. 13.1 is based on *population projections* published by the Israeli Central Bureau of Statistics. (Note: all national statistics agencies publish such projections; It should be easy to replace it with data relevant for your national context). Figure 13.1 shows anticipated changes in the demographic composition of the two largest social groups in Israeli, Jewish and Arab, over two time points. This

| Managerial simulation | | | | | |
|--|--------------|--------------|-------------|--------------|--------------|
| Central Bureau of Statistics: Projections 2005 - 2030 | | | | | |
| Note: Figures are in Thousands | | | | | |
| | Arabs | | Jews | | 2005 |
| Total (000) | % | Number (000) | % | Number (000) | Age |
| | 59% | 800 | 41% | 2,284 | 0-24 |
| | 38% | 512 | 48% | 2,659 | 25-64 |
| | 3% | 44 | 11% | 629 | +65 |
| 6,928 = | 100% | 1,356 | 100% | 5,572 | TOTAL |
| | | | | | |
| | Arabs | | Jews | | 2030 |
| Total (000) | % | Number (000) | % | Number (000) | Age |
| | 47% | 1,115 | 35% | 2,737 | 0-24 |
| | 46% | 1,082 | 51% | 4,004 | 25-64 |
| | 7% | 165 | 14% | 1,129 | +65 |
| 10,232 = | 100% | 2,362 | 100% | 7,870 | TOTAL |

You are a new, motivated manager at [organization]. You received from your senior management the following table, which is based on new data from the Central Bureau of Statistics.

The table shows projections regarding demographic trends among certain social and age groups.

Your task: Please send your personal evaluation and opinions regarding the following 5 key questions:

Q1. What key trends or differences do you see between the social and age groups, for 2005?

Q2. What key trends or differences do you see between the social and age groups, for 2030?

Q3. What key trends or changes do you see between 2005 and 2030?

Q4. What reasons or factors may explain the projected changes between 2005 and 2030, regarding these social and age groups? list key ones.

Q5. Given these trends or changes, what are the implications or impact for long-range planning, and for needed managerial decisions in [organization]? Why?

Fig. 13.1 Sample task: table reading with opinion questions

table is couched in a rich social reality known to all students who undertook this task (40% of whom were from the Arab sector in Israel).

The data table in Fig. 13.1 is comprised only of counts (in thousands) and percentages, which are typical in demographic tables, and are the simplest possible statistics. Thus, the table should be accessible to all students from the middle school level to the college level, even without learning any statistics. However, although the table uses basic figures or what may be seen as rudimentary statistics, it in fact is not trivial to interpret as it shows rather complex patterns: due to its $2 \times 3 \times 2$ design (i.e., social group, age, year), it portrays a *multivariate civic phenomenon* and shows multiple *changes over time*, using a visualization that is more dense than typical

one-way frequency distributions or even two-way cross-tabulations employed in learning introductory statistics. Overall, the data table in Fig. 13.1 offers a rich teaching opportunity, as it illustrates key features of Civic Statistics explained in Chap. 2, and has the potential to serve as a good resource for many observations (by the students) and critical questions (by the teacher and students), and can be the basis for a rich class discussion—depending on whether the teacher can pose suitable opinion questions.

Task Design Notice in Fig. 13.1 both the sequencing and the change in the nature of the questions being asked. Q1 to Q3 cover the first four steps in the Kemp and Kisanne (2010) model described above, and aim to scaffold the thinking process by breaking down for students the table analysis into steps, i.e., first asking about trends or changes in 2005 (top half of the table), then in 2030 (bottom half) and finally across the two timeframes (whole table). This approach to question-posing is used to ensure that students pay attention to the key variables and axes along which the data are organized, and can gradually build a picture of trends and changes within the data, from bivariate to multivariate. This approach is preferred to a generic question such as “what do you notice in the data?”, which is sensible, but in a pilot stage proved confusing for many inexperienced students, who ‘got lost’ in a multivariate three-way data table.

Where Are the Opinion Questions? Q4 and Q5 illustrate the five heuristics listed earlier and summarized in Table 13.1 for shaping ‘opinion questions.’ Q4 addresses the same goal as Step 5 proposed by Kemp and Kisanne (WHY do they change?) but uses a structured phrasing tailored to the specific context used here. Q5, however, adds a new layer and requires that students think about the actual societal, managerial, or economic *implications* of the data. Together, Q4 and Q5 take students from a mere analysis of how numbers change within the cells of a table, to engagement with a real-world context. Q4 and A5 are essential because they force students to think both about the social implications of the data as well as the underlying factors or causes (e.g., social, economic, or other) that affect the actual behaviors of large parts of the population. Thus, Q4 and Q5 are critical to students’ deeper understanding of the projections and their meaning to society and policy.

Class Planning and Task Extension The example in Fig. 13.1 is of course limited by design, being based on a single table and not having information about the social context and variables involved (because the basic demographics were known to all students), nor about richer statistical issues. Nonetheless, the task demonstrates the use of open-ended questions that encourage students to generate an informed opinion based on given data, while making sure students attend to multiple aspects of the data, and connect statistics with social topics.

The interpretation of the three-way table shown in Fig. 13.1, and discussing correlates, causes, conclusions and implications, requires time and patience from the teacher and the students. The analysis may raise issues related to proportional changes, trends, and internal comparisons of counts or percents, and students may

also need some help with terminology regarding the direction or magnitude of the observed changes and patterns, giving rise to a rich mathematical discourse.

Such tasks can be extended since both Q4 and Q5 bring into the class discussion new variables and civic issues (causal factors, correlates, consequences) and a richer multivariate network of interacting factors, each one of which can be further explored. For example, in response to Q4, students may explain that some population groups are projected to grow faster than others due to different birth rates, or that births now happen at older ages (associated with rising education levels for women). Such ideas can be further developed into follow-up tasks where students can be asked to seek additional information on those new variables, e.g., find press releases or reports from an official statistics agency about causal factors or correlates, or by exploring dynamic population pyramids where different modelling assumptions (for example about birth rates) can be made—see Chap. 5. Finally, such a task can be further extended by using richer textual resources (i.e., a newspaper article with embedded statistics, or the press releases on which it is based) covering a broader range of civic topics and statistical information that can give rise to more diverse types of questions and tasks.

13.8 Beyond Opinion Questions: Towards Critical ‘Worry Questions’

This section continues to discuss the third issue of ‘question posing’ noted in Table 13.1. It goes beyond Sects. 13.6 and 13.7 which discussed general ideas regarding the shaping of questions which can tease out students’ general opinions regarding statistics about specific civic issues. Students and (future) citizens need to develop a broader ability to critically evaluate quantitative and statistical messages to the public (Weiland, 2017, 2019). Such messages may be issued by many stakeholders (e.g., politicians, political action groups, civic leaders, journalists, business leaders, etc.) and they are influenced by political, commercial, social, or other agendas which may be absent when statistics are taught in the classroom. Depending on their needs and goals, such sources may not necessarily be motivated to present a balanced and objective report of findings or implications.

To be able to effectively engage and interpret information from such sources, students need to internalize and be able to use some critical questions, which are called ‘worry questions’, to differentiate them from the questions posed *to* the students in class. Worry questions are expected to be deployed whenever students or citizens see data claims, i.e., messages purporting to be based on data or on quantitative evidence. Ten examples for worry questions are offered in Table 13.3—but many more do exist!

The need to develop a broad ability to critically evaluate messages (including quantitative and statistical messages communicated via print/text only, even without any numerals or mathematical symbols), and worry about underlying motives and

Table 13.3 Ten examples for worry questions

-
1. Where did the data (on which this statement is based) come from? What kind of study was it, and is it reasonable in this context?
 2. Was a sample used? How was it derived? How many people actually participated? Is the sample large enough? Did the sample include people/units which are representative of the population? Is the sample biased in some way? Overall, could this sample reasonably lead to valid inferences about the target population?
 3. How reliable or accurate were the measures (tests, questionnaires, interviews) used to generate the reported data?
 4. What is the shape of the underlying distribution of raw data (on which this summary statistic is based)? Does it matter how it is shaped?
 5. Are the reported statistics appropriate for this kind of data, e.g., was an average used to summarize ordinal data; is a mode a reasonable summary? Could outliers distort the true picture?
 6. Is a given graph or chart drawn appropriately? Does it distort or exaggerate trends in the data (e.g., the relative difference between groups)?
 7. How were any probabilistic statements derived? Are there enough credible data to justify the estimate of likelihood given?
 8. Overall, are the claims made here sensible and supported by the data? e.g., is correlation confused with causation, or a small difference made to loom large?
 9. Should additional information be made available to enable me to evaluate the plausibility of these arguments? Is something missing? e.g., did the writer ‘conveniently forget’ to specify the base of a reported percentage change, or the actual sample size?
 10. Are there alternative interpretations for the meaning of the findings or different explanations for what caused them, e.g., could an intervening variable affect the results? Are there additional or different civic implications that are not mentioned?
-

Adapted from Gal (2002)

intentions, has been a recurring theme in writings of many scholars interested in adults' basic skills (Frankenstein, 1989; Freire, 1972; Huff, 1954). For example, Paulos (1995) noted that originators of messages regarding diseases, accidents, or other human problems can make them appear more scary by choosing to report absolute numbers (e.g., “2500 people nationwide suffer from X”), or downplay them by using incidence rate (e.g., “only 1 in every 100,000 people suffer from X”).

Given such considerations, we need to develop our students' *ability and willingness* to worry about the reasonableness of statistical and quantitative claims presented in the media and social networks, the validity of messages, the credibility of the evidence presented, and possible alternative interpretations of conclusions conveyed to them. When faced with arguments or messages involving Civic Statistics, we want people (and students) to have internalized worry questions, so they become habits of mind—immediate reactions whenever faced with arguments involving data. Weiland (2019) further discusses the connection between critical questions in mathematics and statistics education.

The answers students generate to questions such as those listed in Fig. 13.1 can support a critical evaluation of statistical messages and lead to the creation of more informed interpretations and judgments. This list can of course be modified and expanded, and some of its elements regrouped, depending on the life contexts and functional needs of different learners and teachers. Ridgway et al. (2016) illustrate a

way in which learners can be encouraged to build on these ten ‘worry questions’ by deriving their own ‘worry questions’ from errors in political speeches that are reported by ‘fact-checking’ organisations. These organizations offer on their websites a rich source of analyses of statements about Civic Statistics, and students can be asked to analyse and categorise the mistakes made and compiled on these websites. Hopefully, students will use the practical experiences of working with expert critiques of authentic texts to internalize the ‘worry questions’ they develop.

13.9 Summary and Implications

The development of statistical literacy at the school and university levels alike is essential, if graduates are to function effectively in a world filled with rich Civic Statistics. This is the justification for the first of the six key recommendations emerging from the ProCivicStat project—see Chap. 4—which calls on educators to *Develop activities which promote engagement with social issues and develop learners' critical understanding of statistics about key civic phenomena.*

However, developing the ability to critically understand Civic Statistics poses multiple challenges. Hence, this chapter has examined selected issues and dilemmas in this regard. The chapter highlights that developing understanding of the *context* within which Civic Statistics are used (by various stakeholders) and generated (e.g., by official statistics providers, other data producers, or the media itself) is an essential component of teaching for statistical literacy in general and teaching about Civic Statistics in particular.

The use of rich and engaging contexts in the classroom has many advantages, in terms of students’ motivation, development of core reasoning and argumentation skills, and deeper understanding of statistics and mathematics. However, working on ‘meaningful and important’ contexts is far from being simple for educators, if they are only focused on developing their students’ technical mastery of statistical constructs and methods, or prefer to avoid sensitive social issues and hence choose to engage only neutral topics.

For this reason, the chapter posed four questions for educators to consider:

- What contexts are valuable (meaningful and important) for my students?
- How can contexts be meaningfully engaged with in my classroom (via the use of meaningful textual sources)?
- What tasks or questions can I pose about statistics in context, and how can questions and tasks be scaffolded so as to develop students’ ability to express and justify *opinions* about Civic Statistics and about their social implications?
- What are the best *worry questions* for my students to internalise about statistical or data-based claims?

The chapter provided several examples for its core ideas. Other chapters in this book provide many more illustrations regarding contextualization, task design, question-posing, and teacher options. The arena of statistical literacy is much wider (See Gal, 2002; Gal & Ograjenšek, 2017; Watson, 2013; Weiland, 2017, 2019), and more

issues need to be addressed when teaching for statistical literacy, including how to assess learners' knowledge (Ziegler & Garfield, 2018). Further, 'contexts' and 'opinion questions' were discussed here mainly in connection with findings based on datasets and surveys that are in typical use by statistics producers, but are of equal importance for critical understanding of messages and public communications related to chance, risk, and probability (See Gal, 2005).

The ideas in this chapter have many implications for the design of instruction about Civic Statistics and about statistics in general, in diverse teaching contexts, and can help to transform statistics teaching into a more active and engaging form of learning. The chapter implies that students should be asked to *read* and *engage* with meaningful texts about Civic Statistics topics. This in turn requires changes in how much time and effort are allocated to teaching core statistical ideas vs. discussing them *in context*, and designing instructional tasks that reflect a genuine 'need to know' and are motivating for students because of the chosen contexts and realistic and meaningful questions posed about them.

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