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ORIGINAL ARTICLE

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# A classroom-ready activity on educational disparities in the United States

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**Abstract**

We present a classroom-ready activity for high school or college students involving an investigation of a rich, multivariate data set concerning educational and demographic characteristics of K-12 schools at the state level in the United States. The data set includes educational characteristics such as per-pupil revenue and graduation rate along with demographic characteristics such as poverty rate and economic segregation. Analysis of the data set sparks conversations regarding educational disparities for students in the United States and could prompt curiosity about educational disparities in other locations as well.

**KEYWORDS**

teaching, teaching statistics, educational equity, multivariate data, exploratory data analysis, IDSSP

## 1 | INTRODUCTION

This classroom-ready activity, *Uncovering Educational Disparities*, centers on a topic of international social relevance: inequities in the quality of education offered to different demographic groups of students. These inequities are often related to students' social class, race or ethnicity, and indigeneity. Education researchers worldwide have documented unequal government investment in schooling [10,25], disparate experiences of schooling [12,16,23], and differential outcomes including test scores, degree attainment, and career preparation [2,21,24]. Each country's educational system has its own unique contours, but we believe that the United States makes a very interesting case study for secondary and college students regardless of their nationality. In addition, instructors and students in other countries may be inspired by this activity to gather and study similar data in their own contexts.

We have compiled the data set used in the activity from several sources [14,17–20,25]. It includes data from the United States related to elementary and secondary education (ages 6-18 years) from 49 of the 50 states during 2013 and 2014 (Hawaii could not be included because it does not generate data in a way comparable to the other 49 states). The state databases attempt to be a complete census of students in the state, rather than a random sample.

The variables in the data set include measures of high school graduation rates along with statewide poverty rates and school expenditures from local sources (mainly property taxes), state governments, and the national government. In the United States, property taxes depend on the market value of local real estate. Consequently, locations with more families living in poverty tend to have less local funding available for their schools. We also include measures of economic segregation (the degree to which people live in areas of concentrated poverty or concentrated wealth) and racial segregation (the degree to which people have been clustered into neighborhoods that are similar by race). Historically, residential segregation in the United States was enforced by explicitly racist

This content has not been published or submitted for publication elsewhere. It has been shared with 6-10 faculty in the United States for them to use in their classrooms as part of an NSF-funded project.

  

policies such as Jim Crow laws, redlining in mortgage lending, and race-restrictive deeds on houses. Although these policies are now outlawed, "de facto" segregation continues to this day.

## 1.1 | IDSSP alignment

The *Uncovering Educational Disparities* activity is aligned with several aspects of the International Data Science in Schools Project (IDSSP) framework [9]. First, it gives students an opportunity to engage in the IDSSP's cycle of learning from data (see Figure 1). This is highlighted through the cycle images inserted throughout the activity. Second, it provides a rich data set with both quantitative and categorical variables. Additionally, it provides the opportunity to make choices between plots and critique different plots for the same data set.

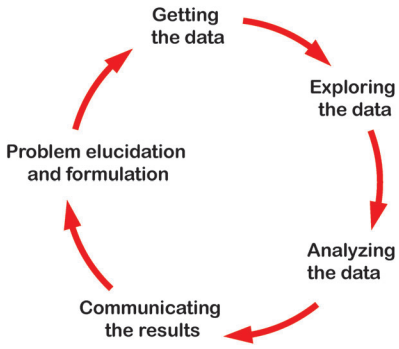


**FIGURE 1** The basic cycle of learning from data. Reprinted from Reference [9], p. 8. Copyright 2019 by The International Data Science in Schools Project [Colour figure can be viewed at wileyonlinelibrary.com]

During the activity, students make and explore a variety of plots to visualize relationships in the data (see Figure 2), including a stacked dot plot displaying a third categorical variable through dot coloring. Using multivariate plots like this dot plot helps students think about things like confounding variables and multiple influences, which is increasingly important now that multivariable data sets are available to the average person and are more commonly used in the workplace. Instructors also have the opportunity to help students see the distinctions between plotting paired, quantitative data with a scatterplot vs. plotting the same data in two unlinked dot plots; paired vs. unpaired study design and data interpretation is a key issue to address in the statistical investigation process. In another part of the activity, one quantitative variable is shown disaggregated by a categorical variable, resulting in two dot plots with no underlying paired relationship, and that situation can be compared with the paired-data situation and plots. Using

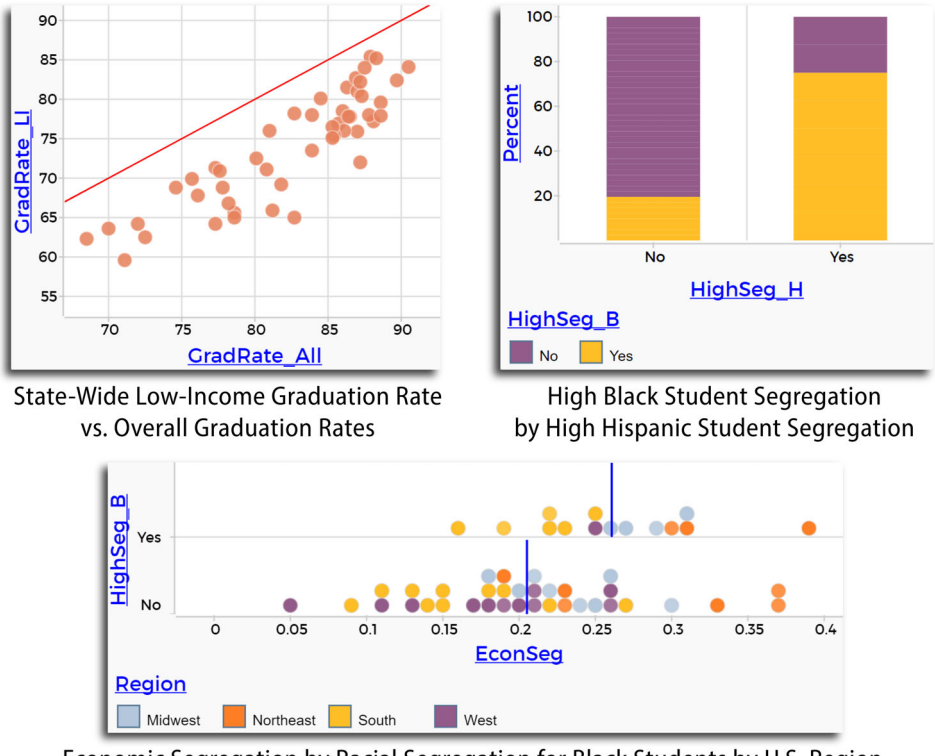


**FIGURE 2** Sample of possible graphs made with the data set in CODAP when completing the Uncovering Educational Disparities activity [Colour figure can be viewed at wileyonlinelibrary.com]

multivariate plots and examining different plots for a data set are included in IDSSP's 1.2-1.4 BTEA topic areas.

### 1.2 | Activity information

This activity is adapted from an introductory statistics curriculum we have developed as part of the *MODULE($S^2$): Statistical Knowledge for Teaching* project [3]. We have implemented the curriculum with college students, but it would also be appropriate for secondary students. This activity is from the curriculum's first unit on Exploratory Data Analysis. The data set is housed on the free data exploration website CODAP (codap.concord.org), and in order to follow and understand the activity the reader should refer to the CODAP file at https://bit.ly/EdDataUSAstates (A CSV file is also available in the online supplement to this article: Data S1). If you plan to use the activity, it may benefit your students to first have them go through an introduction to CODAP [5].

In discussing the data context with students, it was important to us not to reinforce stereotypes about racial, ethnic, and socioeconomic groups. We did not want to lapse into "gap-gazing," looking only at the gaps in certain educational outcomes (eg, high school graduation) for people from different groups without challenging widespread assumptions about the reasons for those gaps. Prior to the class session in which we used this activity, we had our students watch a documentary video [22] to learn more about factors that contribute to some students not finishing high school. That way, they were able to see structural inequity at a personal level before looking at the aggregate level. In our class, we also set the stage for discussing sensitive social issues by discussing our goals, norms, and guidelines for such classroom discussions.

### 1.3 | Activity: uncovering educational disparities

**View Activity Here** (https://onlinelibrary.wiley.com/doi/10.1002/test.12252/supinfo)

## 2 | DISCUSSION OF ACTIVITY DESIGN PRINCIPLES

The *Uncovering Educational Disparities* activity incorporates several principles of lesson design advocated for by statistics education scholars: active, engaged learning [1,8,13]; moving between data and context [7,8]; and increasing sophistication of graphs and their interpretation [4,6,7,11]. Each of these will be discussed in turn.

### 2.1 | Active, engaged learning

The tasks we offer are short but still complex, in that they do not have one "right" answer but instead ask learners to analyze and compare the different responses offered by their classmates. Students are prompted to ask and then answer their own questions, constructing knowledge along with their classmates [13]. Ainsley & Pratt [1] also emphasize the need for instructional tasks to be *purposeful*. We maintain this sense of purpose by asking students to produce a product (a graph) and make an argument based on what they have produced. This said, our efforts to incorporate authentic, socially relevant data are more than just a pedagogical strategy for teaching statistical skills and concepts. Gal and Trostianitser [8] urge that the statistics we teach in school should prepare students for socially engaged citizenship, and we offer this activity as a concrete step toward that end.

### 2.2 | Moving between data and context

Friel and colleagues' [7] framework suggests that an important element in graph interpretation is the student's knowledge of the context of the data. Gal and Trostianitser [8] emphasize the need for students to move back and forth between data analysis and their knowledge of context. When we ask students to connect their in-class data analysis to what they have been hearing in the media (Question 5), we are teaching this statistical habit of mind. We support this habit further by asking them to predict ahead of time what other data will show based on their knowledge of the context (Question 10), and then compare their predictions to their actual conclusions based on data analysis. Finally, throughout the activity we reinforce interpretation of graphs in the context of the data (see, for example, Question 14).

### 2.3 | Increasing sophistication of graph interpretation

Several scholars have contributed to our understanding of how students learn to interpret graphs, and we have designed our activity so that students are asked to increase their sophistication of graph interpretation as they proceed through the activity. Friel and colleagues [7] have identified characteristics of statistical graphs that students need to be introduced to gradually, with scaffolding, and we have incorporated this approach. Two such characteristics are data reduction (in graphs that are less data-reduced, readers can identify each case, while they cannot identify each case in more data-reduced

graphs) and axis scaling. In Question 13, students move in sequence from less-reduced to more-reduced data displays and from axes displaying frequencies to relative frequencies (see Figure 3).

In Question 9, students create a scatter plot and interpret it in context. Next, they add the line $f(x) = x$ to the graph and are asked to interpret the points on the plot with respect to this reference line. Here, they are being asked to combine their algebraic knowledge of functions with their emerging statistical understanding of scatter plots, advancing the sophistication of interpretation of the graph.

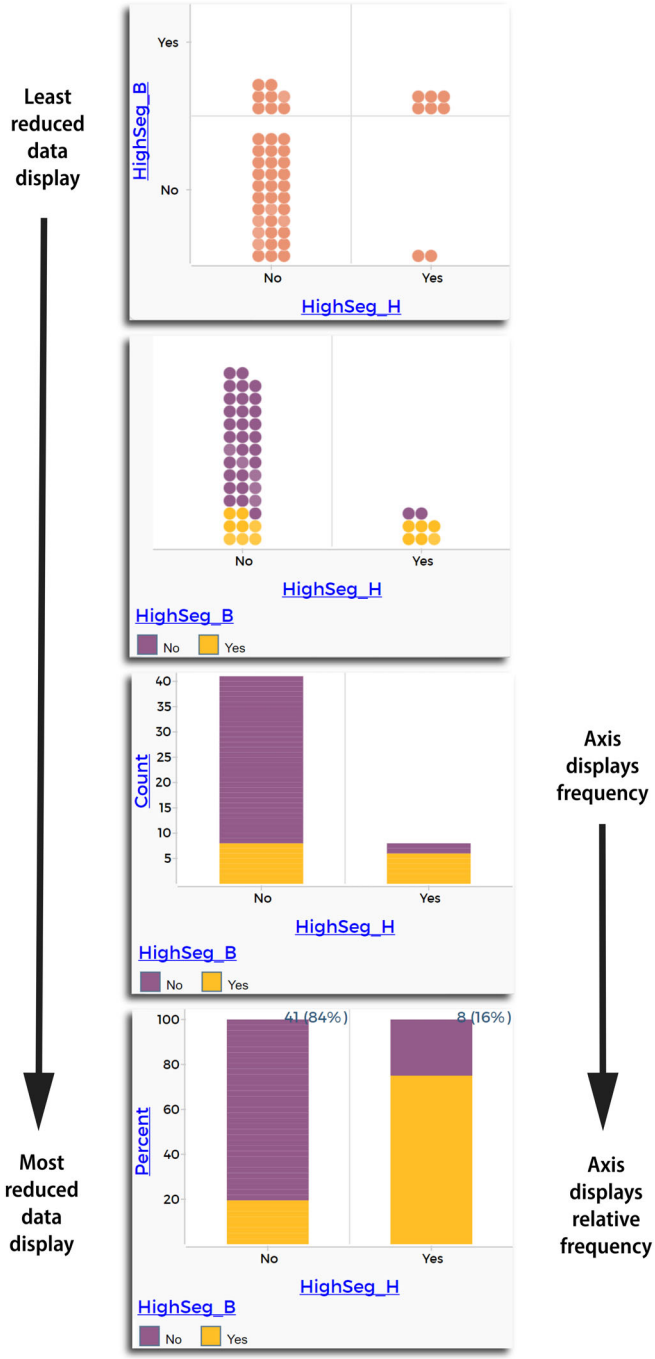


**FIGURE 3** Sequence of graphs made in Question 13 [Colour figure can be viewed at wileyonlinelibrary.com]

Another way we consider the sophistication of graph interpretation is drawn from Curcio's framework [6], where students learn to read the data, read between the data, and read beyond the data. We ask questions corresponding to these levels in sequence: we first ask students what elements of the data spark their curiosity (Question 2), then later ask them to compare two distributions (Question 7), and finally to generate a hypothesis about the real-world context that might explain their findings (Question 11). Similarly, Konold and colleagues [11] have shown that students who are learning to interpret graphs tend to begin with a case view of the data, followed by a classifier view, and finally an aggregate view. We follow this trajectory by asking students to click on one dot at the beginning of the activity (Question 1). Near the end of the activity (Question 13) they are asked to interpret a binned two-way dot plot, which lends itself to a classifier view. Note that at this stage, they are looking for the first time at a graph resembling a contingency table; this will serve to scaffold their later analysis of less obvious instances of categorical association [4]. This graph is then followed by a segmented bar graph, the most aggregated view of the data (Question 14).

## 3 | CONCLUSION

We have carefully and deliberately designed the *Uncovering Educational Disparities* activity to engage students in a meaningful data investigation that advances both their understanding of statistics and an important societal concern, the quality and fairness of education. We hope that you find this activity worthwhile for you and your students. Additional resources related to this activity include an online instructor guide with follow-up exercises, a CSV file of the data set, and an answer key for the activity and its follow-up exercises. Please see the Supporting Information section at the end of this article.

### AUTHOR CONTRIBUTIONS

All three authors have contributed substantially to the manuscript and are in agreement with its content.

### CONFLICT OF INTERESTS

The authors declare no conflicts of interest related to the manuscript.

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## REFERENCES

1. Ainley J, Pratt D. It's not what you know, it's recognizing the power of what you know: Assessing understanding of utility. data and context in statistics education: Towards an evidence-based society. Paper presented at: Proceedings of the Eighth International Conference on Teaching Statistics (ICOTS8); 2010.
2. J. Anyon, *Social class and the hidden curriculum of work*, J Educ 162 (1980), 67–92.
3. S. Casey, A. Ross, S. Maddox, & M. Wilson, *MODULE($S^2$): Statistics for secondary mathematics teaching*, Mathematics of doing, understanding, learning, and educating for secondary schools, APLU, Washington, DC. (2020).
4. C. Batañero et al., *Intuitive strategies and preconceptions about association in contingency tables*, J Res Math Educ 27 (1996), 151–169. https://doi.org/10.2307/749598.
5. The Concord Consortium. Getting started with CODAP. CODAP. 2020. https://codap.concord.org/releases/latest/static/dg/en/cert/index.html#file=examples:Getting%20started%20with%20CODAP
6. F. Curcio, *Comprehension of mathematical relationships expressed in graphs*, J Res Math Educ 18 (1987), 382–393. https://doi.org/10.2307/749086.
7. S. Friel, F. Curcio, and G. Bright, *Making sense of graphs: Critical factors influencing comprehension and instructional implications*, J Res Math Educ 32 (2001), 124–158. https://doi.org/10.2307/749671.
8. Gal I, Trostianitser A. Understanding basic demographic trends: Connecting table reading, task design, and context. Promoting understanding of statistics about society. Paper presented at: IASE Roundtable Conference; 2016.
9. IDSSP Curriculum Team, *Curriculum Frameworks for Introductory Data Science*, The International Data Science in Schools Project, Canberra, Australia, 2019.
10. J. Kenway, *Challenging inequality in Australian schools: Gonski and beyond*, Discourse: Stud Cultural Polit Educ 34 (2013), 286–308. https://doi.org/10.1080/01596306.2013.770254.
11. C. Konold et al., *Data seen through different lenses*, Educ Stud Math 88(2015), 305–325. https://doi.org/10.1007/s10649-013-9529-8.
12. A. Lareau, *Social class differences in family-school relationships: The importance of cultural capital*, Sociol Educ 60 (1987), 73–85. https://doi.org/10.2307/2112583.
13. Z. Libman, *Integrating real-life data analysis in teaching descriptive statistics: A constructivist approach*, J Stat Educ 18 (2010), 1–23. https://doi.org/10.1080/10691898.2010.11889477.
14. List of regions of the United States. Wikipedia. 2018. https://en.wikipedia.org/wiki/List_of_regions_of_the_United_States.
15. T. McCarty and F. Bia, *A Place to be Navajo: Rough Rock and the Struggle for Self-Determination in Indigenous Schooling*, Lawrence Erlbaum Associates, Mahwah, NJ, 2002.
16. J. Mjis, *Stratified failure: Educational stratification and students' attributions of their mathematics performance in 24 countries*, Sociol Educ 89 (2016), 137–153.
17. National Center for Education Statistics. Digest of education statistics. 2013. https://nces.ed.gov/programs/digest/d13/tables/dt13_211.60.asp
18. National Center for Education Statistics. Public high school 4-year adjusted cohort graduation rate (ACGR), by race/-ethnicity and selected demographics for the United States, the 50 states, and the District of Columbia: School year 2013–14. 2015. https://nces.ed.gov/ccd/tables/ACGR_RE_and_characteristics_2013-14.asp
19. Native Americans in the United States. Wikipedia. 2020. https://en.wikipedia.org/wiki/Native_Americans_in_the_United_States.
20. G. Orfield, J. Ee, E. Frankenberg, G. Siegel-Hawley, *Brown at 62: School Segregation by Race, Poverty, and State*, Civil Rights Project, UCLA, Los Angeles, CA, 2016.
21. S. Reardon, *The widening income achievement gap*, Educ Leadersh 70 (2013), 10–16.
22. Reel Works Teens, American dropout [Video file]. WNET. 2012. https://www.youtube.com/watch?v=sOL1Y00l-ek
23. A. Shoshana, *Ethnographies of "a lesson in racism": Class, ethnicity, and the supremacy of the psychological discourse*, Anthropol Educ Q 48 (2017), 61–76. https://doi.org/10.1111/aeq.12183.
24. G. Spindler, *Why have minority groups in North America been disadvantaged by their schools?* in *Education and Cultural Process: Anthropological Approaches*, 3rd ed., G. Spindler, Ed., Waveland Press, Prospect Heights, IL, 1997, 96–109.
25. A. Tilsley et al., *School Funding: Do Poor Kids Get Their Fair Share?*. Urban Institute, Washington, DC, 2017. http://urbn.is/k12funding.

## SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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