How to Become Data Literate: The Basics for Educators

By Susan Rovezzi Carroll and David J. Carroll

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After a long period of intensive dedication to my dissertation, I had finally achieved my goal of becoming a research methodologist with a Ph.D. specializing in applying mixed methods research designs to educational issues. Although I was eager for a bit of a respite, I needed to begin preparing for my next teaching assignment—a course on statistical data analysis. At only 121 pages, *How To Become Data Literate: The Basics for Educators* (2015), promised relatively light reading and an opportunity to learn what the authors, Susan Rovezzi Carroll and David J. Carroll, viewed as critical skills for those faced with the task of making evidence- and research-based decisions in educational settings.

In their introduction, Carroll and Carroll argue that "*data literacy* is the solution" (p. viii, emphasis in original) to the problem of using data to map educational results and steer educational improvement. Educators, they explain, have important questions and no shortage of data. What educators need, they argue, is a basic understanding of research methodology and a working knowledge of statistics. The authors' purpose in writing this book was to support—and encourage—educators in their endeavor to become data literate. The book is intended to be a user-friendly and conceptually accessible introduction to basic data analysis that avoids unnecessarily complex statistical jargon and equations, inspires readers with a can-do enthusiasm, and clarifies how to use data to inform practice.

Although I have some reservations about whether the book thoroughly accomplishes its goals, I wholeheartedly support the authors' purpose. Just a few years ago, I would have been in their target audience. As a new graduate student, I was intent on studying the intersection of mathematics and literacy education. Because I identified as a classroom teacher, I wanted to acquire sufficient statistical skills to understand the nature of evidence-based and research-based practices. To conduct my own research, I knew I would need to draw sound conclusions from data. Despite a background in theoretical mathematics, I was unsettled about the prospect of applying statistical procedures learned in a classroom course to actual problems in social contexts. At the outset, I had no intention of becoming a research methodologist, an expert who studies the advantages and disadvantages of using various research methods and examines how—and to what extent—the results they produce are valid and applicable in practice. Like many educators dedicated to improving their craft and instruction in their content area, I was focused on learning the particular methods necessary to meet my particular goals.

My experiences with enthusiastic and expert professors who specialize in various research methods (e.g., action research, qualitative research, mixed methods research, and quantitative research) contributed to my evolution into a research methodologist. To date, I have accrued substantial experience teaching graduate-level statistics to students from a wide range of programs that foster social science research agendas (e.g., educational studies, school counseling,

nursing, criminal justice). Because the courses I teach are offered by the College of Education at the University of Cincinnati, most of my students are in the target population identified in the preface of *How To Become Data Literate*—"educated professionals that must use, analyze, and translate data" (p. viii) to improve educational outcomes in elementary, secondary, post-secondary, or professional settings. I reviewed this book from the perspective of a methodologist and an instructor.

Because all of my students face, to some degree, increasing accountability requirements and pressure to make data-driven decisions in their work, they are all aware that, as the authors state, "data is now everyone's job and everyone's concern" (p. viii). However, some students are hesitant—or even outright reluctant—to develop quantitative data analysis skills, or *data literacy* as it is referred to in this book. Often, these hesitant students indicate a concern that reflects the three issues the authors describe as obstacles to becoming functional in a data-driven world. Some students describe memories of struggling through courses in mathematics, statistics, or research methods. Other students recognize that engaging with data is time-consuming and worry it may be a distraction from, rather than a means to, doing work they value. Finally, some students question their ability to accurately produce and interpret statistics.

As I read the book, I thought about two things. First, I was interested in understanding what Carroll and Carroll saw as a best approach for helping hesitant learners develop data literacy. Susan Rovezzi Carroll is a former professor of research methodology and program evaluation at the University of Connecticut. As the founder and president of Words & Numbers Research, Inc. (WNR), she has experience conducting research in consultation with the U.S. Department of Education and the National Science Foundation. David J. Carroll, the Vice President of WNR, is her co-author and colleague. In addition to conducting educational research, WNR works with corporate and nonprofit organizations such as hospitals. WNR also offers consulting services to students completing dissertations and faculty conducting research. Given their extensive experience working with various stakeholders in multiple research communities, I was eager to know what Carroll and Carroll believe are critical knowledge and skills for educators.

Second, I was interested in whether this book might be a useful resource or supplemental text for students enrolled in my research methods courses. The required book for the statistics course I teach includes the kind of theoretical explanations, mathematical notation, and application problems one might expect to see in a statistics textbook. It is not uncommon for my students to question whether the formality and complexity of the text facilitates or obfuscates their learning. The endorsement on the back cover of *How To Become Data Literate* suggests this brief book is the antidote for such cumbersome textbooks. As I read, I critiqued the book in terms of its adequacy in helping readers become informed consumers and users of research and proficient producers of research in relationship to the data literacy demands of the course I teach.

Description and Summary

The book is divided into eleven chapters. A glance at the table of contents makes it easy to see that each of the chapters is brief, with most being about 10 pages in length. Most of the chapter

titles are devoid of statistical jargon. The effect is an overview of the book that will appear welcoming and accessible to readers with no prior knowledge of statistics. However, the informal chapter titles and absence of an index will make it difficult for novices to use the book as a resource to review common terms such as standard deviation.

The first three chapters review the basics (i.e., visualizing and summarizing data) with which many educators have some familiarity. In the first chapter, the authors reiterate that the book is not intended to be a formal statistics text. They provide a definition and describe the benefits of statistics. In addition, the authors introduce the terms for the four measurement scales commonly used in quantitative analysis: nominal, ordinal, interval, and ratio. The second chapter explains how to summarize a data set graphically. Eschewing technology, they explain how to create a frequency distribution using tally marks and draft a frequency polygon using paper and pencil. The chapter concludes with a brief discussion of common graphs including histograms, bar charts, and pie charts.

In the third chapter, the authors explain how to use tallies and tables and basic arithmetic to determine the measures of central tendency: mean, median, and mode. These descriptive statistics, the authors argue, are a way of "presenting a mountain of data with one number" (p. 30). Readers in the target audience will appreciate the authors' reassurances that statistical analysis need not be overwhelming. However, from my perspective as an instructor, the claim that "with one single number you can obtain an accurate picture of your entire distribution" (p. 31) is debatable at best and misleading at worst. Astute readers will discover, upon reading further, that understanding the usefulness of a measure of central tendency depends on other factors such as the measurement scale and variance.

The next two chapters are intense by comparison to the first three. In these chapters, the authors lay the groundwork for understanding the statistical tests presented in later chapters. Chapter 4 discusses variability in data and measures of dispersion: range, variance, and standard deviation. In addition, this chapter introduces the normal curve, standard scores (z scores), and skewed distributions. Given the brevity of the chapter, the authors do a fine job of highlighting critical issues related to these complex concepts and providing examples applicable to educational practice. Chapter 5 compels the reader to think about sampling as a "time management" (p. 54) issue. Although it is true that sampling techniques can be used to reduce data collection and analysis efforts, understanding sampling as a methodological issue with implications for generalizability is paramount for educators with ready "access to volumes of data" (p. vii) and the responsibility to use available data in practice. The authors do address this, describing sampling procedures and sample size as important considerations for making warranted inferences from sample to population. In addition to highlighting random sampling as the gold standard for quantitative analysis, the authors discuss rationales and cautions associated with these other sampling procedures common in education—cluster sampling, stratified sampling, and convenience sampling.

Chapter 6, only nine pages long, covers the basics of inferential statistics. The authors begin by explaining the essence of the phrase *statistically significant* and how it relates to probability. A statistically significant result means, they explain, "that our observed outcome is so unique that it could not have occurred by chance alone" (p. 64). The rest of the chapter offers more detail

about null hypotheses, significance levels (alpha), Type I and Type II errors, and power. In anticipation of the complexity to come, the chapter concludes with a four-step heuristic appropriate to all null hypothesis significance testing: state the null and alternative hypotheses, state a level of significance, conduct the statistical analysis, interpret the results. The authors make the difference between statistical significance and practical significance explicit by reminding the reader to question what actions might be warranted in light of the statistical results and what actions might be best given practical constraints such as funding and staffing. This chapter, although brief, touches on a number of very difficult topics while offering educators insights into the ethics of educational research.

Chapters 7 to 10 cover the four statistical tests that the authors consider to be "user-friendly, pragmatic, and applicable in educational settings" (p. 63): t-test, one-way analysis of variance (ANOVA), chi-square goodness of fit, and correlational analysis. For each statistical test, a chapter is dedicated to addressing the basics, including what kind of questions the test is designed to answer, what kinds of data and assumptions the test requires, and a general description of the process for conducting the statistical test. Each chapter includes an example, a discussion of extensions or alternatives to the test, and recommendations for reporting the results of the test. Interestingly, for each example, values for the test statistic (t, F, x^2, or r) are provided with little explanation, and readers are instructed to refer to a statistics textbook for a formula or use software of their choice to produce statistics of interest in their own work. For the most part, the advice is, despite differences in the formality of the language and the omission of the calculations, typical of most statistics books and includes occasional reminders to consult with experts as needed.

Given the length of the book, I had expected it to present less content than the text I use for my course, and this proved to be true. However, as an instructor, I wish that the authors had volunteered more explicit statements about the limitations of the book throughout, perhaps suggesting resources for extending learning beyond the book. In some places the content is simplified without clear warning that a rich topic is presented in an abbreviated form. For example, I have concerns about a table on page 106 that proposes practical interpretations (i.e., low, moderate, high) based on the value of correlation coefficients. Carroll and Carroll are not alone in making such recommendations. For example, Lomax and Hahs-Vaughn (2013) provide a table based on Cohen's (1988) work. However, best practice is to ground interpretations of the strength of correlations—and effect sizes in general—in sufficiently similar empirical evidence (Finch, Cumming, & Thomason, 2001; Hill, Bloom, Black, & Lipsey, 2008).

The authors close the book with a brief, but important, final chapter about the challenges of disseminating results to stakeholders, and they offer some logical suggestions. For example, reports should be organized using bold or italics in meaningful and consistent ways (e.g., to identify headers and terminology). In addition, reports should include simple tables or graphs to illustrate findings in a way that facilitates comprehension for the audience. They also offer some recommendations that are, far too often, missing from statistical textbooks. For example, the authors advise readers to keep ethical implications in mind and to treat the audience, whether experts or laypersons, with respect and dignity.

Discussion

Reading this book gave me insight into what the authors view as essential statistical concepts for educators. By example, the book offered suggestions about how to make statistics accessible to my students. In addition, the concise chapters and discussion pressed me to consider how to reduce complex topics to essentials for an audience of educators. As I reflected on the question of whether my students might find this book useful as a resource or supplemental text, I was conflicted. My reservations revolve around three overarching issues—the framing of data literacy, the use of terminology, and the approach to producing statistical results.

Framing Data Literacy

Implicitly, the authors define data literacy as quantitative literacy or statistical proficiency. Although this is not uncommon, it is troublesome in the context of educational research. In addition to quantitative data, educators have ready access to a formidable amount of qualitative data that can be analyzed and harnessed to improve education. There are compelling arguments for the view that mixed methods (i.e., the integration of both quantitative and qualitative data and analytical techniques) are essential for solving complex problems related to education (e.g., Mertens, 2015). For educators who value qualitative data and consider it essential for contextualizing quantitative data, this book will be unsatisfying. The authors point out that "wise educators must look beyond statistical significance when making data driven decisions" (p. 70), but do not describe pragmatic ways for weighing statistical results against other forms of data in the process of making those decisions.

Assuming that data literacy requires statistical proficiency, the book provides a reasonable introduction to statistics with the potential to support the development of the "confident attitude" (p. x) and self-efficacy the authors intended. However, it does not offer enough breadth or depth to prepare readers as independent consumers or producers of statistics. The book does not cover important introductory topics such as linear regression or logistic regression, nor does it address any advanced techniques that are common in educational research such as multivariate statistics or hierarchical linear modeling. Readers who select the book hoping this quick read will answer all their questions about how to effectively use data in decision-making will be disappointed. Readers looking for a gentle and intelligible initiation into quantitative research and statistics will find what they need to get started. Educators who have taken statistics in the past will find that the abridged treatment of statistics in this book provides a relevant review of central concepts.

Using Terminology

From the outset, the authors took on a major challenge in trying to explain statistics "in language everyone can understand" (p. v). The language of statistics has evolved over many years with concise terms emerging to encompass complex concepts. Given the dense meaning of statistical terms, I had doubts that statistics could be explained in everyday language in such a short volume. I was pleased to find that, in general, the authors did a good job of explaining the statistical terms introduced in the book explicitly and briefly. As described previously, I

particularly appreciated the way in which the authors clarified the meaning of *statistically significant*, a term that is often misunderstood.

However, some of the vocabulary that was introduced appeared to be unnecessary or out of place. For example, in chapter 2, the *ordinate axis* and *abscissa* of a graph were defined when *vertical axis* and *horizontal axis*, respectively, would have sufficed. Also, the terms *platykurtic* and *leptokurtic* were defined and illustrated as a flat curve and a peaked curve, respectively, in advance of the chapter explaining the normal curve. In most statistical texts, the normal curve is introduced first, since the terms platykurtic and leptokurtic describe the shape of curves in relationship to the normal curve. After reading the entire book, I believe some terms, including those discussed here, could have been omitted without compromising the essence of the discussion.

Of special interest to me, as a mixed methods research methodologist, was the authors' description of the difference between qualitative data and quantitative data. Defined in the chapter titled *Speaking the Language Correctly*, the definition of *qualitative data* did not match my understanding of the term. They describe qualitative data as categorical variables or "observations that are descriptive" (p. 4). In contrast, I would describe qualitative data as unstructured data such as interview transcripts. I believe their use of the term qualitative data will confuse readers familiar with the data and methods used in action research, qualitative research, or mixed methods research (Cochran-Smith & Lytle, 2009; Hatch, 2002; Plano Clark & Ivankova, 2016). I was surprised that the authors were not more circumspect and did not offer the readers the caveat that different research traditions use similar words to convey different meaning.

Producing Statistics

Due to the low-tech approach to producing statistics, this book will be more useful to readers who wish to become consumers of statistics. As promised, the authors avoided mathematical equations and technical explanations. Their goal was to make the text more accessible, presumably by way of reducing the cognitive load of reading equations and avoiding the technical difficulty of learning to use technology. Although I agree that the authors met this goal, their approach will leave readers with questions about how to make calculations and how to apply concepts using readily available tools such as Excel by Microsoft or SPSS.

To avoid mathematical equations, the authors used a hybrid of English and mathematical notation to describe how to make calculations. For example, in chapter 8 the calculation for degrees of freedom for ANOVA is explained in this sentence: "The Within Groups *df* is equal to (the number in each group minus one [n-1]), and then the *sum* for each group" (p. 88, emphasis in original). As an advocate for learners with limited ability to read expressions and equations written using symbolic mathematics, I thank the authors for taking on the challenge of writing a statistics book that is readable for everyone. However, based on my research in symbolic mathematics language literacy, I believe that many readers in the target audience would identify the hybrid text (which uses Arabic numbers, parentheses, and brackets in novel ways within an English language sentence) as more difficult to read compared to the simple formulas used in other statistics texts (Headley, 2016). By comparison, Lomax and Hahs-Vaughn (2013) describe

the degrees of freedom for the within groups as N-J, where N is the total number of observations and J is the number of groups.

The book does not provide instruction related to the use of technology for generating visualizations of data, calculating descriptive statistics, or conducting null hypothesis significance testing. As a mathematics educator, I understand that making graphs and calculations by hand has the potential to deepen conceptual understanding by offering insight into how the process imbues the result with meaning. However, in a book that argues that "statistics is a tool for time management" (p. 54), I found the absence of recommendations for user-friendly applications or software odd. For example, the authors explain how to interpret a standardized score using a table that requires readers to use row headers, labeled with z scores rounded to the nearest tenth, and column headers, labeled from 0.00 to 0.09, to determine the z score to the nearest hundredth (p. 51). I was unable to see how this procedure, which involves decomposing the z score (e.g., reconceptualizing a z score of 1.34 as 1.3 + .04), would contribute to conceptual understanding or avoiding the tedium often associated with statistics. I had expected the authors to refer the reader to a free online statistics calculator (e.g., http://www.danielsoper.com/) or, at the very least, provide a more user-friendly table (e.g, Lomax & Hahs-Vaughn, 2013, p. 757).

Conclusion

The two most notable things about *How to Become Data Literate* are the book's length and the reading level. On the one hand, I was excited that the book was short and easy to read. In just a few days of reading, I got a refresher course covering a semester of introductory topics in statistics. On the other hand, I found myself wishing the book was a little bit longer and had a little more depth. As a statistics instructor considering recommending the book as a supplement, I wish it covered more topics and offered resources for extending the content. In addition, I wish it had a glossary and index to make it more useful as a reference. Ultimately, the book is what the authors intended to write—an easy-to-read statistics primer for educators.

This book will be a welcome alternative to textbooks among educators who worry that they do not have the time or ability to make sense of the methods behind "data-driven decision making" (p. v). By explaining the gist of statistics and providing concrete examples applied to simple problems in schools and classrooms, the book provides an entry point for practitioners who need to negotiate debates about how to translate research into practice. For educators who want to become active users and producers of data, this book should be viewed as a springboard—not a user's manual— to becoming data literate. I will keep this book on my shelf, ready to share with those students who request a supplement "written in English" to make sense of their textbook. The contrasts between this light read and our heavy textbook will allow me to raise important questions about what it means to understand data and use data in the service of improving education.

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