

Data Literacy 101: Understanding Data and the Extraction of Insights

Kirk Paul Lafler, sasNerd

ABSTRACT

Data is everywhere and growing at extraordinary rates, making a strong foundation in data essentials more important than ever. This paper introduces the fundamentals of data literacy, highlighting how to derive meaningful insights and apply them to decision-making tasks. Attendees will:

- ✓ Learn about the types of data (nominal, ordinal, interval, and ratio).
- ✓ Understand how to assess the quality and reliability of data.
- ✓ Explore datasets using effective visualization techniques.
- ✓ Apply selected statistical methods to describe, summarize, and analyze data.

By the end of the session, participants will be equipped with practical skills to interpret data confidently and use it to support evidence-based decisions.

INTRODUCTION

Data can tell an essential story about the challenges facing an organization and, often, the best way to handle these challenges – at least if you take the time to listen to your data. But data alone isn't sufficient. To gain the greatest advantage with your data, you must learn how to use it effectively. This paper will guide you through the steps to help strengthen your understanding of your data, by enhancing your data literacy skills. What does this mean? You will learn valuable techniques to effectively measure changes in your data, understand data patterns, and extract insights from your data.

DATA LITERACY 101

Data literacy refers to the ability to take a data file, ask questions about the data, and come to conclusions about the data. A data literate person can read, clean, transform, analyze, and engage with data in a way that provides meaning to others. A data literate person may also demonstrate competency in using tools such as SAS, Python, R, and other software, tools, and technologies.

The good thing to recognize about data literacy is that you don't need to be a data scientist, statistician, or other professional to possess data skills. And, because data is everywhere, employees, managers, and other stakeholders can build data literacy skills by embracing and promoting a data culture within and throughout an organization.

THE IMPORTANCE OF DATA LITERACY

A basic understanding of data is important for everyone in an organization to have. The benefits of being able to read and interpret the different types of data, data files and their structures, datasets, metadata, and other data content include:

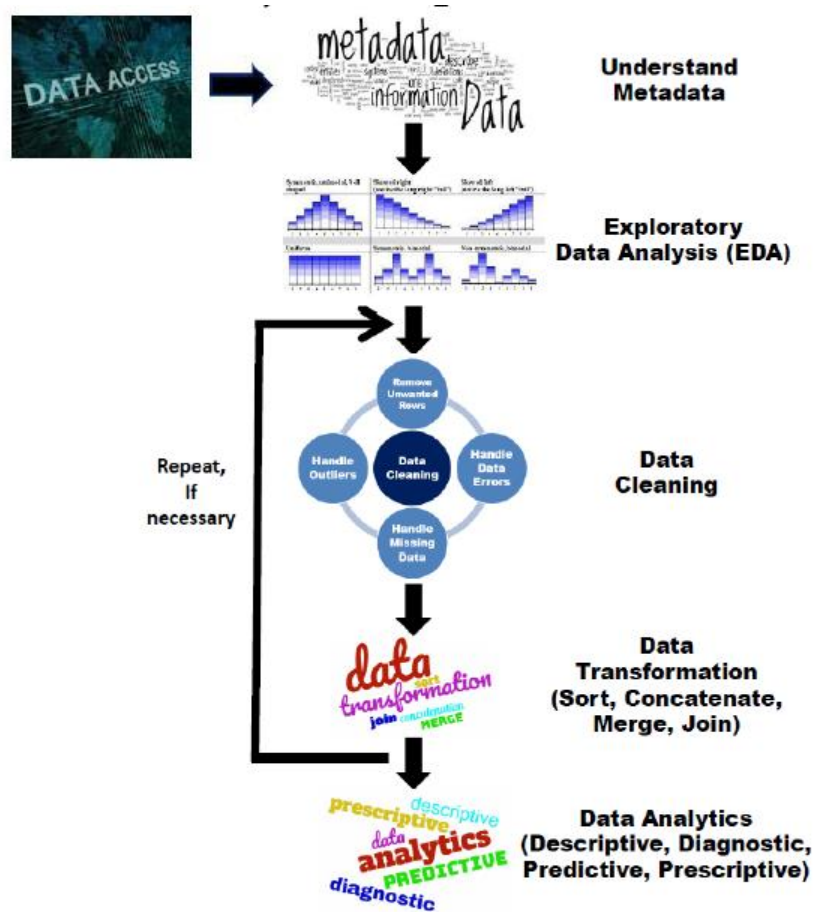
- ✓ The ability to ask more intelligent questions and receive more accurate answers about an organization's operations and processes.
- ✓ The ability to enhance productivity by having a better understanding about your data.
- ✓ The ability to make better decisions for yourself, your team, and your organization.
- ✓ The ability to gain a competitive advantage over your competitors by using available data sources.

THE RISK ASSOCIATED WITH BEING DATA ILLITERATE

The risk and downside of not having data literacy skills (or being data illiterate) is that it can contribute to the spread of misinformation due to the misinterpretation of data and/or results. For example, a data illiterate person may not be able to:

- ✓ Identify data-related issues (or data standards) in the data.
- ✓ Identify the latest (or most current) data sources to use in analysis.
- ✓ Identify the “best” statistical test to use with your data.
- ✓ Identify the most appropriate visualization technique to best understand the data and/or results.

THE PROCESS OF UNDERSTANDING AND USING DATA



DATA CHALLENGES

Many data challenges face organizations in the 21st century. A list of the most notable ones include:

- ✓ Inability to access standardized and clean data.
- ✓ Inability to handle big data issues related to Volume, Velocity, and Variety.
- ✓ Organization and/or staff resistance to adopting a data-driven culture.
- ✓ Inability to define a clear set of objectives about what is needed for data analysis.
- ✓ Not knowing the “best” data visualization technique to use when trying to understand your data.
- ✓ Inability to process the desired data for analysis and reporting purposes.
- ✓ Identifying Key Performance Indicators (KPIs) for decision-makers.
- ✓ Inability to select the right analytics tool.
- ✓ Inability to advance from data to analytics to results.

One of the greatest challenges you’ll have when working with data is an inability to access standardized, clean, and structured data. Consequently, you’ll be unable to advance from data to analytics to results. When this happens, the result is often the loss of valuable information about your data and an inability to make the type of decisions that are based on evidence and facts. Instead, decisions are made on nothing more than generalized perceptions.

Another data challenge is having too much or vast amounts of data, often resulting in an inability to process and/or store large data sizes. This can also result in finding and fixing data quality issues. Another issue with big data is it’s forcing organizations to evaluate and select big data technologies. From Hadoop to Apache Spark, traditional databases to NoSQL databases – the choices are many. Without using the right tools, the result can quickly escalate with out-of-control expenses and unscalable processing of large quantities of data.

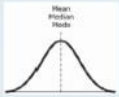

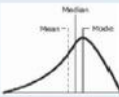
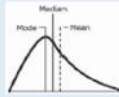
QUALITATIVE VERSUS QUANTITATIVE DATA

| Data Scale | Description |
|--|--|
| Nominal Data (Qualitative, Categorical) | Nominal data is the 1 st level of measurement and is qualitative in nature – containing alphabetical and/or numbers, cannot be ordered, measured, or used in arithmetic operations. Nominal data is typically used for labeling purposes or for classifying data into mutually exclusive categories, but no order exists between the categories. Examples include gender, marital status, hair color, ethnicity, “yes/no”. |
| Ordinal Data (Qualitative, Categorical) | Ordinal data is the 2 nd level of measurement and has a set order to it with the data possessing an order or ranking capability. But like nominal data, ordinal data cannot be measured or used in arithmetic operations. Examples include letter grades, education level, position in a queue, frequency, Likert-type questions. |
| Discrete Data (Quantitative aka Integer) | Discrete data is countable and involves whole numbers (integers) which can be quantified, have arithmetic operations performed, and contain values of a finite nature. Examples include sports scores, population numbers, products in inventory, and grains of sand. |
| Continuous Data (Quantitative aka Interval and Ratio) | Continuous data is measurable, quantifiable, and can possess an infinite number of values. This type of data is further classified into two categories: Interval data and Ratio data. Interval data is the 3 rd level of measurement and represents a numerical scale with order known along with the difference between the data values, but a “true zero” or a fixed beginning cannot be determined. Examples include population, rainfall, temperature, elevation, IQ score, SAT score, year. Ratio data is the 4 th level of measurement and displays order, the difference between data values, and information about “true zero”. Examples include age, height, weight, income, sales, market share, unemployment rate, product defect rate, distance, area. |

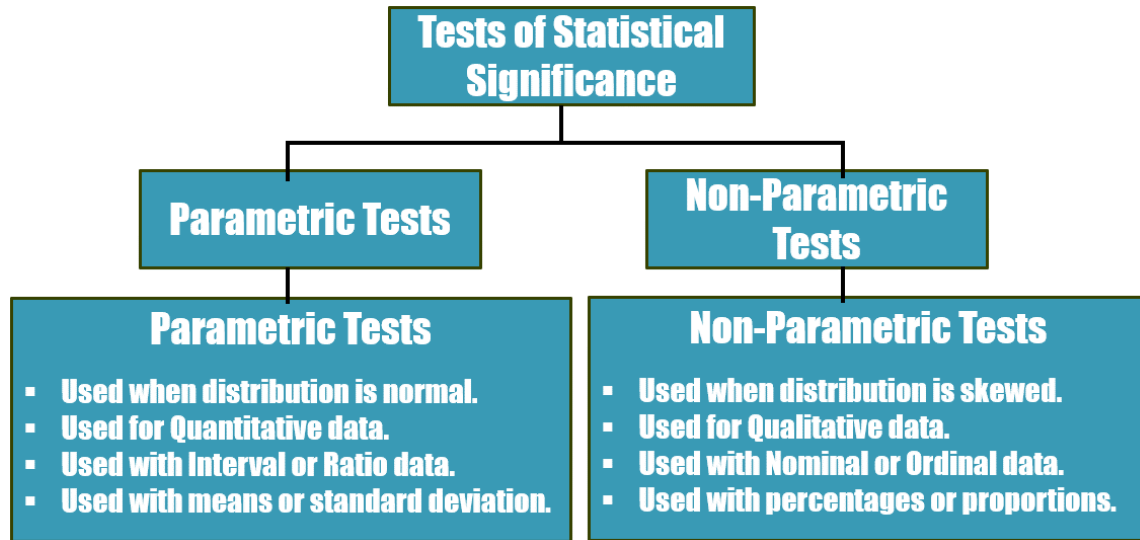
APPLICATION OF DATA SCALES TO STATISTICS

| Data Scale | Mathematical Operations | Measures of Central Tendency | Measures of Variability |
|-----------------|---|---|---|
| Nominal | Equality (=, EQ, NE) | Mode | None |
| Ordinal | Equality (=, EQ, NE) Comparison (>,<) | Mode Median | Range Interquartile Range |
| Interval | Equality (=, EQ, NE) Comparison (>,<) Addition (+), Subtraction (-) | Mode Median Arithmetic Mean | Range Interquartile Range Standard Deviation Variance |
| Ratio | Equality (=, EQ, NE) Comparison (>,<) Addition (+), Subtraction (-) Multiplication (x), Division (-) | Mode Median Arithmetic Mean Geometric Mean | Range Interquartile Range Standard Deviation Variance Relative Standard Deviation |

QUANTITATIVE DATA ATTRIBUTES

| Attribute | Description |
|-----------------|--|
| Shape | <p>The shape or symmetry of data in a dataset refers to how the points are distributed throughout the set. A popular way to view the shape of data is with a histogram. The data arrangement or shape displayed by a histogram are frequently referred to as:</p> <ul style="list-style-type: none"> ▪ Symmetrical (Uniform)  ▪ Bimodal  ▪ Left-skewed  ▪ Right-skewed  |
| Center | The center in a dataset describes the location of a typical data point value. Three measures of center are the arithmetic mean (average), median, and mode. |
| Spread | The spread in a dataset describes the variation of the data. Typical measures of spread are the range, quartiles, standard deviation, and variance. |
| Outliers | An outlier in a dataset describes a data value that is much smaller or larger (or lies outside) most of the other values in a random sample produced from a population in a set of data. Two popular ways to view outliers is visually with a box plot and with statistical tests such as z scores to determine extreme data points. |

TESTS OF STATISTICAL SIGNIFICANCE



LEVELS OF MEASUREMENT IN STATISTICS

| Descriptive Statistic | Nominal | Ordinal | Interval | Ratio |
|----------------------------------|---------|---------|----------|-------|
| Mean | | | Yes ① | Yes ① |
| Median | | Yes | Yes ② | Yes ② |
| Mode | Yes | Yes | Yes | Yes |
| Range | | | Yes | Yes |
| Standard Deviation | | | Yes | Yes |
| Variance | | | Yes | Yes |
| Coefficient of Variation | | | | Yes |
| Categorizes and Labels Variables | Yes | Yes | Yes | Yes |
| Ranks Categories in Order | | Yes | Yes | Yes |
| Possesses Known, Equal Intervals | | | Yes | Yes |
| Possesses a "True Zero" | | | | Yes |
| Frequency Distribution | Yes | Yes | Yes | Yes |

Legend: ① Not skewed
 ② Skewed

STATISTICAL TESTS FOR ANALYZING DATA

| Statistical Test | Nominal | Ordinal | Interval | Ratio |
|---|----------------|----------------|-----------------|--------------|
| Chi-square Goodness of Fit Test ① | Yes | | | |
| Chi-square Test of Independence ① | Yes | | | |
| Mood's Median Test ② | | Yes | | |
| Mann-Whitney U-test ② | | Yes | | |
| Wilcoxon Matches Pairs Signed Rank Test ② | | Yes | | |
| Kruskal-Wallis H Test ② | | Yes | | |
| Spearman's rho (Rank Correlation Coeff.) ② | | Yes | | |
| T-test ① | | | Yes | Yes |
| ANOVA ① | | | Yes | Yes |
| Pearson's r ① | | | Yes | Yes |
| Simple Linear Regression ① | | | Yes | Yes |

Legend: ① Parametric – estimating the parameters of a probability distribution.

② Non-Parametric – does not make any assumptions of the characteristics of the sample or whether the observed data is quantitative or qualitative.

DATA FILE TYPES AND DESCRIPTIONS

| File Type | Description |
|--|--|
| SAS Data Set (SAS7BDAT) | A proprietary SAS (SAS7BDAT) data format owned by SAS Institute Inc. that organizes and stores data values in the form of rows (observations) and columns (variables). A SAS dataset is processed by the SAS software as a temporary or permanent table of data in a SAS library (i.e., WORK, SASUSER, and User-assigned). |
| Tab-separated Text (TSV) | A text data format known as, a tab-separated values (TSV) data file, is created and used by spreadsheet programs and other software. A TSV data file contains rows of data values organized into one or more fields (or columns) where each data value is separated (or delimited) with a tab character. |
| Comma-separated Values (CSV) | A popular text data format that contains rows of data values organized into one or more fields (or columns) where each field is separated (or delimited) with a comma. |
| Excel (XLSX) | A proprietary data format owned by Microsoft Corporation and used to format, organize, store, and compute data in Excel spreadsheet software. |
| JavaScript Object Notation (JSON) | An open standard data format that is used to transmit web application data. |

DATA FILE TYPES AND DESCRIPTIONS, continued

| File Type | Description |
|--|---|
| HyperText Markup Language (HTML) | HTML is widely used to access data from websites. There are a variety of ways to access or scrape data from HTML including a Yahoo-developed tool called YQL. |
| Relational Data Base Management Systems (RDBMS) | There are numerous RDBMS systems including Oracle, MySQL, Teradata, SQL-Server, DB2, Sybase. Users typically interact with RDBMS technology using SQL to access data. |
| GIF, JPG, TIFF, and PNG | These are popular image file formats used on websites and file / photo viewers. |
| W3C-Recommended (RDF) | Uses URLs as identifiers. |
| eXtensible Markup Language (XML) | Widely used as transport files to maintain the structure in data. |

WAYS TO IMPROVE DATA LITERACY SKILLS

The good news is that you don't necessarily need to be a data scientist to use and interpret data effectively. To be successful, you'll need to develop and hone a series of data literacy skills. A few suggestions to help improve data literacy skills include:

- ✓ Acquire basic software skills → SAS, SAS Studio, Python, R.
- ✓ Practice data cleaning techniques using "open" online data files.
- ✓ Practice data transformation techniques such as sorting, concatenation, merges / joins, and transposes.
- ✓ Study examples of the various techniques → data access, visualization, etc.
- ✓ Seek out and practice "best" practice techniques and guidance.
- ✓ Read published papers on LexJansen.com and SAS Communities.
- ✓ Attend and/or participate at conferences → SESUG, MWSUG, WUSS, PharmaSUG, Local SAS User Groups, ASA, Analytics Groups.
- ✓ Enroll in beginner, intermediate, and advanced online courses (you may even find some that are free).
- ✓ And most importantly, Have Fun and Enjoy the journey!

EXTRACTING INSIGHTS FROM DATA

Once you’ve developed your skills and understanding about data, you’ll be able to apply your newfound knowledge to collect, clean, transform, analyze, and interpret your results. With practice, you’ll learn how to improve your decision-making skills, communicate your findings, and produce positive outcomes to help your organization be more successful with all that data.

Adhering to the following steps will help make your journey easier. Practice, and soon you’ll become a pro.

| Task Step | Not Complete | In Progress | Complete |
|---|---------------------|--------------------|-----------------|
| Form a Team <ul style="list-style-type: none"> - Experienced data user - Data Manager | | | |
| Establish Goals and Metrics <ul style="list-style-type: none"> - Identify questions you need answers to - Identify the metrics that will be used to measure your goal results | | | |
| Identify, Inventory, Gather Data <ul style="list-style-type: none"> - Collect Quantitative Data - Collect Qualitative Data | | | |
| Assess and Discuss Data Needs <ul style="list-style-type: none"> - Review datasets - Identify observations - Revise questions, as necessary - Assess whether additional data is needed | | | |
| Analyze Data <ul style="list-style-type: none"> - Clean data, as necessary - Transform data, as necessary - Perform an exploratory data analysis (EDA) - Identify data patterns - Identify data inconsistencies - Identify changes over time - Compare data to other data - Discover root causes | | | |
| Plan and Evaluate <ul style="list-style-type: none"> - Align data points to determine outcomes - Monitor and evaluate - Refine (or optimize), as necessary | | | |

CONCLUSION

Acquiring data literacy skills is essential for anyone seeking to maximize the value of data. This paper introduces the fundamentals of data and provides practical guidance on strengthening your data literacy. By following a clear, step-by-step process, you will learn valuable techniques to measure changes in data, identify meaningful patterns, and extract actionable insights.

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TRADEMARKS

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AUTHOR CONTACT INFORMATION

Kirk Paul Lafler is a data scientist, consultant, developer, programmer, educator, and author who teaches Statistics, SAS Programming, and Data Management in the Department of Statistics at San Diego State University. Kirk also delivers project-based consulting and programming services to organizations across healthcare, life sciences, business, and other industries. As an experienced instructor, he teaches both *virtual* and *in-person* courses in SAS, SQL, Python, R, Database Management Systems (Oracle, SQL Server, Teradata, MySQL, MongoDB, PostgreSQL, AWS), Excel, cloud, and other technologies.

Kirk currently serves on the Western Users of SAS Software (WUSS) Executive Committee as the Open-Source Advocate and Coordinator, and he is actively engaged with multiple proprietary and open-source user groups and conference committees. As the author of several books, including the widely acclaimed [PROC SQL: Beyond the Basics Using SAS, Third Edition \(SAS Press, 2019\)](#), Kirk is an invited speaker, educator, keynote, mentor, and is the proud recipient of 29 “Best” contributed paper, hands-on workshop, and poster awards.

Comments and suggestions are always welcome and can be sent to:

Kirk Paul Lafler, sasNerd

Data Scientist, Consultant, Developer, Programmer, Educator, and Author

Specializing in SAS® / Python / SQL / Database Management Systems / Excel / R / AWS / Cloud-based Technologies

E-mail: KirkLafler@cs.com

LinkedIn: <https://www.linkedin.com/in/KirkPaulLafler/>