

# Effective Data Visualisation for Researchers

Principles, Tools and Applications

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## Preface

The growing need for researchers to present their findings in a visually striking and academically rigorous way led to the development of this book. As PhD students in physical education and health promotion at the University of Cape Coast, we have seen firsthand the difficulties many students face in choosing the right visual tools to communicate their data effectively. This book has been written with a deliberate focus on accessibility and practicality. We tried to distil complex principles and technologies of visualisation into simplified, actionable knowledge, suitable for those at the beginning of their academic research careers.

While the focus is on academic research, the principles and procedures described in this piece can be extended to professional reports, trade presentations, and policy documents where data-driven reporting is essential. We hope that this book will not only improve the technical skills of the reader but also give them a deeper understanding of the role of visual literacy in the research process. We are grateful to our mentors, colleagues, and students for giving us feedback and support throughout this process. This book is for all researchers and readers who seek truth, meaning, and progress through the written word.

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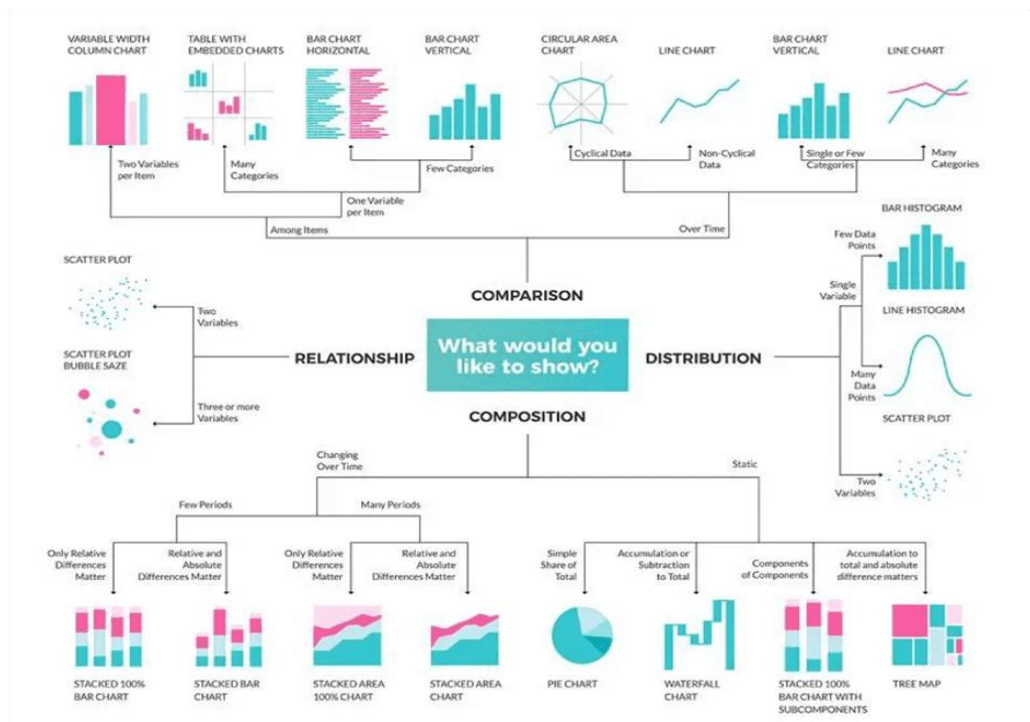
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# Chapter 1: Introduction to data visualisation

Data visualization is a purposeful and strategic process which aims to present data in a way that is effective and clear. It involves much more than just creating interesting charts and lively diagrams. Graphical display of information and data using visual elements such as charts, graphs, maps and infographics is called data visualization. People can see and understand trends, outliers, patterns, and relationships within data sets that may otherwise be difficult to understand using only raw numbers by using visualization tools that incorporate visual elements.

The main objective of data visualization is to facilitate the access, understanding and use of complex data. It helps people to understand numbers quickly and efficiently by converting abstract data into a concrete visual context. Data visualization facilitates decision-making, reporting, narrative and exploration of data in both academic and professional environments. In addition, it provides relevant information in an efficient way, which makes it easier for different audiences to understand complex research findings and underlying patterns. Effective data visualization turns complex numbers, complex relationships, and complex patterns into visualizations that are not only easy to understand, but also deeply emotional for viewers.

A well-designed visualization helps researchers, policy makers and the general public quickly identify correlations, anomalies and important insights. It acts as a key link between raw data and human understanding. In this respect, data visualization is one of the most important tools for using data to create narrative interventions. It turns confusing research into compelling narratives that viewers can relate to and become more receptive to the implications of the data. Data visualization raises the level of engagement and ensures that complex information is presented in a way that is both meaningful and educational, using well-designed colours, shapes and interactive elements. This guide helps you choose the best scenario for your story.



## Importance of Data Visualisation in Research

Data is a powerful tool in academic research, helping to guide decision-making, support arguments and inform conclusions. However, numerical or textual raw data may be intimidating and difficult to understand. Transparency is crucial here. non-disclosure. Graphical display of information and data using visual elements such as charts, graphs, maps, and infographics is called data visualisation. It helps to translate complex data sets into understandable, concise and relevant visual representations, which make it easier to identify trends, patterns and outliers. Data visualisation is essential to enhance the quality and accessibility of research findings in academic studies.

For example, in a study of teenage pregnancy prevalence by a graduate student, bar and pie charts were used to graph the distribution of teenage pregnancy in different counties. These images enabled stakeholders, such as local health officials and legislators, to identify high-risk areas and understand the scale of the problem. Data visualisation is also helping to make evidence-based decisions in the areas of agriculture, education and public health. For example, the Ministry of Health often shows regional distribution of diseases such as COVID-19 and malaria using choroidal maps. Using this visualisation, health officials can more effectively allocate resources and implement targeted interventions.

In the realm of academic research, data visualisation plays a crucial role by offering several significant benefits:

1. **Simplification of Complex Data Sets:** Researchers can make complex and large-scale data easier to understand by translating it into a visually familiar format such as an infographic, chart or graph. Professionals and laypeople alike can now understand details without having to sift through a sea of unprocessed data through this simplification.
2. **Revelation of Patterns, Trends, and Relationships:** Heat maps and scatter charts are two examples of data visualisation techniques that help researchers to identify underlying trends and patterns that may not be immediately apparent from raw data alone. This visual representation offers a deeper understanding of the subject and also helps to detect correlations and anomalies.
3. **Facilitation of Comparison Across Variables:** By comparing different variables side by side, visualisation tools allow you to explore the interaction between them. For example, bar charts can help researchers to quickly see the dynamics between different factors and show changes in population demographics over time.
4. **Effective Communication of Research Findings to Diverse Audiences:** Sharing academic research results with a wide audience, such as stakeholders, policy makers and the general public, is often necessary. Effective visualisation can simplify complex concepts into short, captivating images, improving understanding and memory, while ensuring that important ideas are understood by people with different levels of experience.
5. **Enhancement of Credibility and Impact of Academic Work:** Visualizations by professionals increase the credibility of the survey and increase participation. The rigour of the research process can be highlighted, findings can be more persuasive to funding agencies, peers and the general public, and the overall impact of the research can be enhanced by clear and convincing graphics.

Word clouds and thematic maps are powerful tools for qualitative research, helping to visually represent key topics raised in focus groups or interviews. These dynamic images highlight the most commonly used words and phrases in an engaging way, offering a powerful snapshot of the main ideas and concepts. They reveal underlying patterns and emotions by transforming qualitative data into visually arresting and vivid representations. These vivid images encourage a deeper engagement with the findings, which makes the results not only easier to understand, but also much more powerful and poignant.

## **History and Evolution of Data Visualisation**

The concept of representing information visually is not a modern invention. The earliest examples of data visualisation, such as maps, star charts, and diagrams, date back to the time of the ancient civilisations. For example, the oldest map ever found was found in an ancient Babylonian city, dating back to about 600 BC. Scholars and researchers began



to illustrate geographic, statistical, and social data using more structured data visualisation techniques in the 17th and 18th centuries. Graphs such as bar graphs, line graphs and pie charts were first used in the late 1700s by prominent figures such as William Playfair, who is considered the father of statistical graphics.

The 19th century witnessed significant advancements, particularly with Florence Nightingale's polar area chart (also known as the "coxcomb chart") that visualised causes of mortality during the Crimean War, and Charles Joseph Minard's famous flow map of Napoleon's 1812 Russian campaign, which is still regarded as a masterpiece of visual storytelling.

The digital age, particularly from the late 20th century onward, revolutionised data visualisation. The advent of personal computers, spreadsheets, and specialised software like Microsoft Excel, Tableau, and the R programming language expanded the accessibility and complexity of data visualisation. Today, interactive dashboards, real-time visual analytics, and immersive visualisation tools have become essential in business intelligence, research, and policy development.

### **Science Behind Visual Perception**

The science of visual perception is fundamental to the efficacy of data visualisation. Human brains are naturally wired to process visual information more efficiently than text or numbers. Research in cognitive psychology and neuroscience has demonstrated that the human visual system can detect and interpret shapes, colours, patterns, and spatial arrangements rapidly. Several key principles underlie the science of visual perception in data visualisation:

1. **Pre-attentive Processing:** Without conscious effort, the human brain can immediately identify certain visual characteristics such as colour, orientation, size, and location. In data visualisation, these features can be used strategically to highlight important components.
2. **Gestalt Principles:** The human perception of patterns and associations of visual elements is explained by these psychological concepts. The grouping and interpretation of data in visual representation may be influenced by concepts such as closure, continuity, similarity and closeness.
3. **Colour Psychology:** In addition to improving aesthetic appeal, colours have cultural and psychological connotations which influence interpretation. When used properly, colour schemes increase the emotional impact and clarity.
4. **Cognitive Load Theory:** According to this theory, users' mental processing capacity can be overloaded by an image that is too complex. Effective visualisations keep things simple and straightforward to avoid cognitive overload.

## Basic Terminologies and Concepts

Learning basic terms and concepts is essential for understanding and using data visualisation in academic research. Below are some fundamental terms explained within the Ghanaian context.

**Data:** Data refers to raw facts, figures, or information collected for analysis. In research, data may include figures on cocoa production, student enrolment rates in Senior High Schools, or malaria cases recorded at an hospital.

**Dataset:** A dataset is a collection of related data organised in a structured format, usually in rows and columns. For example, a dataset might contain information on the number of road accidents from 2015 to 2023, organised by region and year.

**Variable:** A variable is a characteristic or attribute that can take on different values. In a study on household incomes, variables might include household size, monthly income, and employment status.

**Chart Types:** Different types of charts are used based on the nature of the data:

1. **Bar Chart:** Used to compare quantities across categories. Example: Comparing literacy rates in Uganda and Ghana.
2. **Pie Chart:** Shows proportions of a whole. Example: Distribution of national budget allocations to education, health, and agriculture.
3. **Line Graph:** Displays trends over time. Example: Showing the trend of rainfall patterns from 2000 to 2023.
4. **Scatter Plot:** Shows relationships between two continuous variables. Example: Relationship between age and income levels.
5. **Histogram:** Shows the frequency distribution of a continuous variable. Example: Distribution of examination scores for SHS students.

**Axes (X and Y):** Charts and graphs usually have two axes:

1. **X-axis (horizontal):** Typically represents the independent variable (e.g., year, region, category)
2. **Y-axis (vertical):** Represents the dependent variable (e.g., number of cases, percentage, income)

**Data Labels:** These are values or text displayed on a chart to provide additional information about data points. For example, labelling bars on a chart to show the exact values of cocoa production in different regions.

**Legend:** The legend explains the colours, patterns, or symbols used in the diagram. The colour corresponding to each ethnic group in the pie chart showing the ethnic composition of the population of a country would be indicated by a legend.

**Infographics:** An infographic is a graphic representation which uses text, data, graphs and icons to convey information or clearly tell a story. For example, the Statistical Office can summarise the results of the population and housing census using infographics.

**Dashboard:** The dashboard is a user-friendly interface which displays several interconnected visualisations on one screen. Government ministries are increasingly using dashboards to monitor real-time health service performance and economic indicators.

## **Conclusion**

This chapter explores the fascinating field of data visualisation, highlighting its central role in scientific research and its development into the powerful tool it is today. This chapter shows how data-driven decision-making has become a powerful force in influencing research and policymaking at the global level by breaking down the basic jargon and providing eye-opening examples. Giving experienced researchers data visualisation skills will revolutionise the way they present their findings, making their work more persuasive and accessible as the need for impactful and clear communication of findings increases. Readers are encouraged to delve deep into the fascinating world of data visualisation techniques when moving into the next chapter. This journey will reveal a stunning array of possibilities and shed light on the directions that researchers can take with each approach. The main aim is to provide concrete, real-world examples from research in the social economy, health and education fields around the world. The following chapters try to show, through these narratives, how data can be transformed into gripping visual stories that both engage and inform. In addition, it will help researchers present their findings in a powerful and concise way.

## Chapter 2: Understanding types of data and visual representation

Data are the basis of a thriving academic research area and enable robust, evidence-based conclusions to be drawn. The prerequisite for aspiring researchers is to become proficient in different forms of data and in the art of selecting the best visual representations. The inherent characteristics of the data available determine the best visual representations to communicate the findings effectively and clearly, whether you are conducting a study examining complex cocoa production patterns or evaluating the academic achievement of high school students. In this chapter, we embark on an enlightening exploration that will clarify the complex distinction between qualitative and quantitative data. The nominal, ordinal, interval and ratio levels of the measurement will be discussed, as well as how they relate to the specific type of analysis. In addition, we will determine which graphical representations, such as bar charts for nominal data and line charts for interval data, are most suitable for each category. In addition, we will introduce common visual aids widely used in academic research worldwide, including pie charts, scatter charts and trigrams. This will help us to understand better how to present data in visual form, thus facilitating the sharing of research findings.

### Qualitative vs. Quantitative Data

The sharp contrast between qualitative and quantitative data is one of the first things to consider when starting a research trip. These two types of data shed light on different aspects of the subject under study, requiring different strategies for detailed analysis and impactful visualisation. Qualitative data are presented in narrative, narrative insight and rich descriptive language, capturing the complexity of human experience and behaviour, while quantitative data are presented in quantitative numbers, statistics and quantifiable values, which provide accuracy and clarity. Any researcher wishing to present the full picture of their findings must understand this distinction.

Non-numeric information (qualitative data) that highlights the characteristics, qualities and complexity of the subjects is referred to as qualitative information. Questions about the nature of experience, such as what people think, why they feel certain ways, or how

they view their circumstances, are best answered by data of this kind. The techniques used for collecting the qualitative data are generally in-depth interviews, focused group discussions, direct observation and open-ended surveys, which allow the participants to express their opinions in their own words. For example, a rich qualitative insight could be gained from a study looking at the lived experience of women on the market of mobile money services, especially how mobile money services affect their business transactions. In this situation, the participant may report that since using prepaid mobile money, they feel safer carrying less money. prepaid. This not only conveys a personal sentiment but also illustrates how these sentiments affect their daily business operations. These quotes provide an insightful look into the attitudes and perceptions of participants and vividly illustrate how mobile money has revolutionised their lives and businesses.

The numbers (qualitative data) that can be calculated or evaluated methodically constitute a special category of information known as quantitative information. This type of data is designed to provide answers to difficult questions. Examples include the quantity of a given resource, the number of participants, the frequency of a particular event, or the magnitude of a phenomenon. Typically, carefully planned approaches are used to collect quantitative data, such as in-depth surveys, carefully monitored scientific studies, or official documents. Take the case of a public health researcher who fought the deadly COVID-19 pandemic in the Middle East. They can trace the total number of vaccine doses administered each month. This dataset not only demonstrates the effectiveness of vaccination campaigns but also provides a clear demonstration of quantitative data in action. The data obtained can be accurately measured and are intrinsically numeric, which allows accurate statistical analysis. This analysis helps to identify important trends, patterns and insights that are necessary to inform and shape public health strategies and policies to improve the health outcomes of the population.

**Key Differences**

Qualitative Data	Quantitative Data
Descriptive and narrative	Numerical and measurable
Collected through interviews, focus groups, and observations	Collected through surveys, experiments, and records
Analysed using thematic, content, or narrative analysis	Analysed using statistical methods
Example: Reasons for school dropout in rural Ghana	Example: Number of students who dropped out of school in 2024

## Types of Data

Making the right classification of your data is crucial before deciding on a visualization method. Data can be categorised into four main measurement scales, each of which has unique traits and appropriate visual aids.

1. **Categorical (Nominal) Data:** Different groups or classifications, each with their own distinct characteristics but without any inherent order or ranking, constitute categorical data. Fruit varieties, nationality and sex are some examples of this kind of information. These categories are perfect for grouping and comparison without suggesting any hierarchy, as they differ only in their characteristics. Several interesting chart types can be used to represent succinct topics succinctly visually. Bar charts make it easy to compare the sizes or frequencies of categories by showing them as vertical bars. By dividing the data into proportional slices, pie charts give a clear picture of how each category contributes to the total by dividing the data into discrete categories. On the other hand, dot plots provide a dynamic and interactive way to visualise data by spreading out the colours on the graph, each of which represents a category.
2. **Ordinal Data:** Ordinal data is a type of categorical data where categories are arranged in a meaningful way, but the spaces between categories are not always clearly defined or precisely measurable. This means that, although we know the order of the categories, we cannot measure their exact differences. For example, customer satisfaction can be ranked as poor, fair, good, and excellent, indicating an increasing level of satisfaction, and educational levels such as primary, secondary, and tertiary can be seen as increasing levels of attainment. Although there is no clear numerical separation between these categories, they show a progression or progression of severity. Some types of charts are particularly useful for effective visualisation of abstract nouns. Ordered bar charts emphasise the sequential nature of the categories by displaying frequencies in a way that highlights their order, making comparison straightforward. Dot plots represent frequencies with dots for each category, offering a simple and clear view of data distribution across the ordinal scale. When ordinal data can be linked to numerical values, box plots can be used to illustrate the distribution, showing medians, quartiles, and outliers within the ranked categories. Using these visualisation methods helps convey the relationships and differences among ordinal data categories more clearly.
3. **Interval Data:** Interval data is a type of quantitative data characterised by ordered categories with consistent intervals between them, but it does not have a true zero point. This means that the zero value does not indicate the complete absence of the measured attribute. A common example of interval data is

temperature measured in degrees Celsius, where the difference between each degree is uniform, allowing meaningful comparisons; however, zero degrees Celsius does not represent an absence of heat. Similarly, IQ scores are interval data because the differences between scores are consistent and meaningful, yet a score of zero does not signify a total lack of intelligence. Several techniques are proposed for the effective visualization of interval data. By showing the frequency of values at different intervals, histograms are useful for illustrating the distribution of data and for facilitating the interpretation of patterns. Line charts are perfect for showing continuous variables or trends over time and highlight how the data fluctuates at regular intervals. By showing median, quartiles and possible outliers, the box plots provide a concise overview of the data distribution and facilitate efficient and clear comparison between different data sets.

4. **Ratio Data:** A meaningful absolute zero point is added to the ratio data, which is a type of quantitative data which has all the characteristics of interval data. Because this absolute zero allows the calculation of ratios between values and allows meaningful comparisons, such as when one value is twice or half the other, it is necessary. The actual absence of the measured quantity is represented by zero in the ratio data, rather than arbitrary zero values in the interval data. Weight, height, age, and income are all common types of ratio data that can be compared by means of multiple relationships, and all have real zero points. For example, a person who weighs zero kilograms has no body weight, and someone who earns \$80,000 earns twice as much as someone who earns \$40,000. Different types of graphs and charts are often used to visualise ratio data efficiently. By classifying continuous data into bins, histograms show the distribution of frequencies, while scatterplots show the association of two numerical variables with patterns of occurrence or correlations. Line charts are great for showing trends over time and allow users to monitor changes in the ratio data over time. By emphasising the medians, quartiles, and outliers, the box plots provide a clear picture of the central trend and variability of the distribution of the data. Using these visualisation tools improves the interpretation and analysis of ratio data and often provides important insights that might not be immediately apparent from looking at the raw numbers alone.

Summary Table

Level of Measurement	Example	Suitable Graph
Nominal	Ethnic groups in Ghana	Pie Chart, Bar Chart
Ordinal	Ranking of football teams	Bar Chart, Column Chart
Interval	Temperature readings	Line Graph, Histogram
Ratio	Household income	Histogram, Line Graph, Scatter Plot

Common Visual Forms

With a strong understanding of the different types of data and levels of measurement, researchers are ready to take on the fascinating task of choosing the most visually striking image of their findings. Amongst the many other options, three stand out, each with its unique charm and fascination. Tables provide meticulous information organisation, showing data in a clear grid of lines and columns, which requires searching. Graphics, on the other hand, are full of life and vividly illustrate parallelism and trends. They do so by using dynamic models and a palette of vivid colours to draw the viewer in and provide a quick overview. Finally, diagrams highlight connections that might otherwise go unnoticed and simplify complicated concepts by highlighting relationships and processes. Together, these visual aids transform information into convincing narratives that anyone can understand.

Tables

With their carefully designed rows and columns that intersect, tables serve as systematic structures that present both raw data and aggregated values in a consistent and orderly manner. These tables are efficient tools that simplify complex data into visually attractive formats, making both basic comparisons and detailed analyses easier. Users can more easily identify trends, patterns and connections when the data are grouped in these visual representations, which improves their understanding and interpretation of the information displayed. For example;

Region	Malaria Cases	Recovered	Deaths
Ghana	50,000	49,595	5
Togo	30,000	29,994	6
Benin	15,000	14,990	10

Tables are incredibly useful tools for accurately communicating data and for efficiently transforming complex data collections into clear and organised formats. Their strength lies in their ability to visually convey details that might otherwise appear unclear or



confusing. This clarity enables readers to perform analyses more precisely and consume complex datasets. Tables make it easy to compare different values by their organised layouts, which have different lines and columns. They are, therefore, essential sources for anyone who wants to point out specific data points or detect new patterns in large sets of data. Tables add a level of clarity and precision that improves understanding and decision making, whether in academic research, business analysis, or other areas requiring careful data mining.

## Charts

Charts are powerful visual tools that make it easy to show patterns and trends by transforming quantitative data into striking visual images. They allow the viewer to identify connections and insights that would otherwise be obscured by a sea of numbers by presenting them in a lively and well-organised way. Amongst these types and examples are bar charts, pie charts, line charts, historical charts and scatter plots.

## Diagrams

Diagrams successfully convey the complexity of qualitative data by offering a visual representation of complex relationships, dynamic processes, or structured hierarchies. These visual aids can depict different ideas, including mind maps to show the links between ideas, organisational charts to show relationships within a team or business, and flow charts to show the flow of work. By converting abstract information into understandable visual representations, diagrams help people to understand important ideas and connections, which in turn helps them to understand the material. They are very useful in both academic research and in practice because of their ability to see patterns, make clear deductions, and improve problem-solving.

## Types and Examples

1. **Flowchart:** A flowchart is a graphical representation of the sequential progression of a process. It shows the choices or actions needed to complete the task or solve the problem, and the order in which these choices are made, using different symbols (e.g. circles, diamonds, rectangles, and arrows).
2. **Venn Diagram:** The Venn diagram is a visual aid for illustrating the association between different groups or groups of objects. These sets are represented by overlapping circles.
3. **Concept Map:** A concept map is a graphic representation of the links between different concepts, ideas or facts. It facilitates the organisation and structure of knowledge, making connections easier to understand.

## Types of Data Visualisations

Data visualisation has the basic function of conveying a coherent and captivating narrative using facts and figures, beyond mere aesthetics. The choice of the best visualisation technique is crucial for the effective communication of your research findings, especially in an academic context where accuracy and clarity are paramount. By gaining experience with various visualisation techniques, including infographics, heat maps, scatter charts, and bar charts, you will be able to create visual representations that not only improve understanding but also highlight important research findings. Your audience will understand the meaning of your findings regardless of their level of expertise, thanks to your ability to translate complex data into an understandable narrative.

### 1. Comparison Visualisations

The purpose of comparative visualisations is to illustrate the differences and similarities between different categories of products or periods. They help to answer important questions such as which region has the highest literacy rate or how regional differences in school enrolment compare. These graphical comparisons often highlight the variation or progress in important areas such as public health, education and economic development in research. For example, a detailed visualisation could highlight the sharp differences in literacy rates between urban and rural areas, or the gradual increase in school enrollment rates in certain regions, providing important insights into the effectiveness of policies and initiatives to improve access to and quality of education.

#### Types of Comparison Visualisation

1. **Variable Width Column Chart:** Changing the dimensions of the columns and rows in this chart gives you a detailed visual representation that allows you to compare two different values related to each item. For example, comparisons of the enrolment rates of male and female senior high school students in a country show patterns and differences which show equal access for both genders. This comparative analysis highlights enrolment rates while also clarifying the broader implications of gender equality in education in these areas.
2. **Table with Embedded Charts:** The use of tables with small graphs inside each cell allows researchers to view many data points at once. Consider, for example, the detailed government report listing the agricultural production of each of the central region's counties. Mini-bar graphs showing the production levels of staple crops such as cocoa, cassava and maize could be inserted in the report. Researchers can quickly analyse and compare the agricultural performance of different regions and gain a better understanding of regional trends and variations in crop production by visualising these data.
3. **Bar Chart (Horizontal):** This method works particularly well when comparing several categories, especially when dealing with lengthy category names that

require more explanation. An example of how this is being implemented is the ranking of different districts in Northern Ghana by the percentage of households that have access to drinking water. Beyond highlighting regional differences in water availability, this analysis highlights the importance of identifying areas that could require immediate attention and funding to improve public health and well-being.

4. **Bar Chart (Vertical):** When working with a small number of categories, this method is particularly useful, especially when the focus is primarily on the height differences between different groups. For example, a survey of literacy rates in the four main regions of Ghana, like Ashanti, Volta, Western, and Eastern. In this respect, the display of differences in literacy rates makes it possible to understand more clearly the differences in education within a country and to compare the performance of different regions.
5. **Circular Area Chart:** Effective visualisation is the best format for presenting seasonal or cyclical trends in a concise format, as recommended by a reputable newsletter. Take, for example, the monthly distribution of rainfall in Ghana. Using these visualisations, we can obtain important information on annual rainfall variations, which are closely related to the agricultural calendar. Farmers in the area need to understand these trends so that they can plan their planting and harvesting operations during high rainfall periods, maximise yields and ensure sustainable agriculture.
6. **Line Chart:** This is a great tool to show changes over time, especially if you use one or more lines on the diagram. The annual growth rate of GDP from 2010 to 2024 is a good example of the various trends, changes and fluctuations in the country's economic performance over this period. This kind of analysis would allow a comprehensive understanding of how the economic situation has evolved and provide an overview of periods of growth and decline, influenced by various domestic and international factors.

### **Why Use Comparison Visualisations?**

They allow decision-makers, students and policy makers to gain a deeper understanding by quickly highlighting the differences and similarities between different data sets or scenarios. This clarity allows them to identify both sectors where significant progress has been made and the precise areas where intervention is most needed. By presenting this information in an organised way, stakeholders can effectively prioritise their efforts and resources and ensure that action is taken where it will have the most impact and benefit.

## 2. Relationship Visualisations

Relationship visualisation can be used to reveal significant patterns or correlations in research looking at the interaction of two or more variables. This methodology is particularly important in areas such as social science and public health scholarship. For example, it may be very useful to identify and understand the relationship between health outcomes, such as the prevalence of a disease or general health, and educational attainment. Researchers can increase training opportunities and community health services by analysing these relationships to better inform policy decisions and target interventions. Recognition of these links will allow a more thorough understanding of the factors affecting social dynamics and public health.

### Types of Relationship Visualisation

1. **Scatter Plot:** A scatter plot shows individual data points on a vertical (y) and horizontal (x) axis, so that the relationship between two variables can be visually depicted. Consider, for example, a study that looked at the relationship between the rate of children's education in eastern rural communities and the level of household income. Plotting household income on the x-axis and the associated school attendance rate on the y-axis allows researchers to determine whether financial status has a significant impact on educational attainment. This method allows a clear visual analysis of possible trends or patterns in the data.
2. **Bubble Chart:** Altering the size of bubbles adds another dimension and improves understanding of the relationships involved. Consider, for example, the visual representation of the Greater Accra urban districts, where each bubble represents a district and the district's size is based on the population of the district. Unemployment rates are shown on one axis of this two-dimensional graph, and the average educational level of the population is shown on the other. Visitors can easily see trends and differences between the different neighbourhoods of the city thanks to this visual representation, which also successfully illustrates the link between unemployment and educational attainment.

### Why Use Relationship Visualisations?

These techniques allow researchers to explore and clarify complex relationships between different variables, which is essential for testing hypotheses thoroughly and identifying subtle trends that may not be immediately apparent. By examining these interdependencies, we can gain a deeper understanding of the dynamics at work. This research is essential to improve knowledge in the different areas of study and to inform policy.

### 3. Distribution Visualisations

Distribution charts are essential to help researchers understand the distribution of data points in a dataset. This knowledge is particularly important for the analysis of different types of data, as it allows a more thorough understanding of elements such as variability, frequency distribution and identification of key trends. For example, these visualisations can highlight areas of interest or excellence and show patterns of academic performance in the evaluation of student test results. Similarly, in the assessment of health indicators such as disease prevalence or vaccination rates, the distributional visualisations helped to identify trends and gaps in public health and the direct efforts of policymakers to improve overall health outcomes across different countries. Distributional visualisations are a priceless tool for improving our understanding of complex data sets because they effectively represent the distribution of values.

#### Types of Distribution Visualisation

1. **Bar Histogram:** The frequency distribution shows how often different values occur in the same variable. Consider, for example, how well the Nigerian or Ghanaian students performed in the mathematics. This breakdown provides a detailed overview of student performance, highlighting those who fall within different ranges, such as 0-39, 40-59, 60-79 and 80-100. By examining these data, we can learn more about the general academic achievement of math students in this field and identify trends or patterns in their performance.
2. **Line Histogram (Density Plot):** The Data successfully shows trends over time and offers a more accurate representation of the distribution of denominations. Take, for example, the daily average temperature density graph of Tamale during the year. This visualisation allows for a thorough examination of climate change, highlighting patterns and variations that help to explain the dynamics of the region. Scientists can identify trends, anomalies, and seasonal variations in temperature by examining this smoothed curve, which provides important information about local weather patterns and their possible effects on ecosystems.
3. **Scatter Plot:** Scatter plots are a useful tool for showing basic distribution patterns, especially when working with large collections of data points. For example, plotting the age of farmers against the area they farm allows us to observe patterns in the agricultural landscape of the region. Apart from the highlighting of outliers, farmers who significantly deviate from the norm, either because of their age or the size of their operation, the analysis may identify different clusters, indicating groups of farmers with similar age demographics. In addition to facilitating understanding of the demography of farmers, these visual aids provide key data for developing regional agricultural policies and the distribution of resources.

## Why Use Distribution Visualisations?

Statistical visualisations such as histograms, box plots and Q-Q plots are essential for determining outliers in your data set, assessing the normality of your distribution and showing the general form and distribution of your data. These preliminary steps are essential in any analytical process because they shed light on the underlying patterns and features of the data. For example, you can verify whether the objects are real anomalies or legitimate observations by identifying them. Because many statistical tests assume a normal distribution, the standard deviation test helps to select which tests to use. In addition, knowledge of the range, as shown by metrics such as variance and interquartile range, and of the shape, such as whether the data is symmetric or biased, provides a solid basis for more complex analysis and guarantees that the conclusions drawn are accurate and reliable.

## 4. Composition Visualisations

Visualisations of the different components that make up a complex entity are called composition plotting. These visualisations may be dynamic, changing over time to reflect changes in the data, or static, with relationships and proportions being fixed in a single image. Researchers can observe changes in structural patterns, track ratios, and analyse cumulative effects in complex data sets because of this dynamic property. Using these visual aids, scientists can better understand the complex relationships between the components and how they interact to create the larger picture.

### Dynamic (Over Time)

1. **Stacked 100% Bar Chart:** The percentages of the different categories during the specified period are presented in this presentation as percentages. For example, it has been monitoring the shift in public and private school enrollment over the past decade. The analysis sheds light on the shift in the percentage of students attending public schools as opposed to private schools and provides insight into national educational and demographic trends during this period.
2. **Stacked Bar Chart:** This analysis provides a detailed overview of changes in absolute agricultural production volume and value over time. For example, it provides a detailed analysis of the total agricultural production in a country for the years 2015-2020, broken down by crop type. It tries to highlight crop yield variations and their corresponding market values, while providing useful data on regional agricultural trends and economic impacts over time.
3. **Stacked 100% Area Chart:** The analysis highlights the volatility of denominations over time. For example, it provides a detailed example of how many sectors GDP have contributed to the country's growth since 2000 and are expected to continue to do so until 2024. This graphic shows the dynamic interaction between these sectors, highlighting trends such as the growing importance of the services sector, the shift in industrial production and the

continuing importance of agriculture in the national economy. This knowledge could be useful in understanding the broader economic landscape and the long-term impact of policies.

4. **Stacked Area Chart:** This examines changes in both the total volume and its components over a specified period of time. For example, the breakdown of total electricity production from 2010 to 2025 by fossil fuel, as coal, and renewable energy sources, such as wind and hydro. In addition to highlighting trends and changes in energy production, this comparative analysis provides insight into how energy production in the country is evolving towards more sustainable energy practices.

5. **Static (Snapshot at One Time)**

- ✓ **Pie Chart:** Perfect for showing the relative amounts of different components in the total at a particular point in time. It is easy to understand how electricity, coal, liquefied petroleum gas (LPG) and wood contribute to energy consumption by looking at the percentage of each energy source used by households, for example, by using a pie chart.
- ✓ **Waterfall Chart:** This type of graph is particularly useful for showing how each value contributes to the total by showing the rise and fall of the denomination. An example of this is the distribution of the budget by sector. A general picture of the trend in government expenditure over time can be obtained by using a waterfall chart, which can visually display the budget and show areas where appropriations have increased or decreased since the previous financial year.
- ✓ **Stacked Bar with Subcomponents:** This graphic effectively divides the main categories into smaller, easier-to-manage subdivisions. The distribution of the total education budget between primary, secondary and post-secondary education is shown in the stacked bar chart. In addition to showing the relative size of the different segments, this breakdown makes it easier to compare the different levels of funding for education.
- ✓ **Tree Map:** Tree maps effectively show the size and importance of nested categories, while representing hierarchical data. For example, a tree map can graphically show different export categories, such as cocoa, gold, and oil, and the corresponding export values when mapping export commodities. A clear and organised picture of trade relations with its main trading partners can be obtained by ranking each category according to its export value.

## **Why Use Composition Visualisations?**

They provide a detailed description of the internal data structure and illustrate the complex relationships between different components and the overall theme. This knowledge is essential for researchers, educators and policy makers, as it allows them to monitor trends and changes over time and to understand relative relationships in an efficient way. By clarifying these relationships, they can better decide how specific data points contribute to the larger patterns and changes in the context of the study.

## **Visualising Time-Series Data**

The data of the series are classified into discrete periods of time by priority. Visualisation of this type of data is needed to identify trends, seasonal patterns and anomalies that may have occurred over time. Time series visualisations allow you to better interpret and make decisions based on how data changes over time by accurately capturing these temporal changes. Several basic visualisation strategies are often used for time series data. The most commonly used charts are line charts, which are perfect for metrics such as temperature, stock prices, or sales over time, because they show the current changes and trends in the data. By shading the area below the line, area charts improve line charts and make it easier to view cumulative totals such as annual sales or cumulative visitors to a site. When used for discrete or categorical intervals, toolbar charts make it easy to compare values for different months or product categories. Candle charts, which show opening, closing, peak, and trough prices over time, are incredibly useful in the financial industry to illustrate the movements of stock prices and provide insight into market volatility. For example, a line graph showing monthly precipitation for several years may show trends and seasonal variations in rainfall. This visualisation supports understanding of long-term climate behaviour and more informed environmental analysis, allowing viewers to quickly identify patterns such as peak rain seasons or years with abnormally low rainfall.

## **Visualising Spatial Data**

Information related to specific geographical locations or regions is referred to as spatial information. It is easier to identify patterns relating to location, distance and spatial distribution when these data are visualised using maps. Maps are an effective tool for understanding complex spatial relationships and help users to understand the distribution of different elements across the landscape. Several standard techniques are used to visualise spatial data efficiently. Choropleth maps use a range of shades of colour to illustrate the magnitude of a variable across different regions, such as the population density in administrative areas. Using different colours to represent the data values, heat maps show intensity or concentration, making it easier to identify hotspots or clusters. The larger circles on the proportional symbol maps indicate, for example, a larger proportion of the population in cities. These maps use symbols which are scaled to a magnitude proportional to the magnitude of the data. Geographical scatter plots that show spatial distribution and correlations, such as the distribution of businesses or



environmental events in a city, use points to indicate specific occurrences or attributes on the map. For example, the choropleth map, which shows the population density, makes it easy to see which areas are more or less populated. By highlighting areas that may need more care or services because of their population density, this type of mapping helps decision-making processes such as urban planning and allocation of resources. These types of visual aids improve the understanding of spatial data and its use in real estate settings.

## **Visualising Multivariate and High-Dimensional Data**

Multivariate data are data sets containing multiple variables for each observation, which allow for a detailed examination of the relationships and interactions between these variables. By simultaneously capturing multiple dimensions, this type of data makes it easier to understand complex phenomena. This idea is reinforced by high-dimensional data, which involves a huge number of variables. Due to the sheer complexity and volume of information, visualisation and translation are often difficult. Many methods are often used to visualise high-dimensional and multivariate data efficiently. By displaying pairwise scatter plots in a grid, the scatter plot matrix allows the viewer to see correlations and relationships between any two variables. Parallel coordinate plots show patterns across multiple variables simultaneously by representing each variable as a vertical axis and showing the individual data points as lines crossing these axes. While heat maps use colour gradients to represent values in a matrix, which makes it easier to identify trends and anomalies in large data sets, bubble charts improve on traditional scatter charts by adding dimensions to the bubble size and colour. Dimension reduction techniques are often required for extremely high-dimensional data to simplify visualisation without sacrificing important information. Principal component analysis (PCA) reduces complexity while preserving important data variability by converting the original variables into a smaller set of uncorrelated principal components. Similar to this, t-distributed stochastic neighbourhood embedding (t-SNE) clusters similar points to facilitate visual interpretation when mapping data to two or three dimensions. Teachers can, for example, identify which factors are most strongly correlated with academic achievement and target interventions by using a scatter plot matrix of student performance metrics, such as test scores, attendance, participation, and grades.

## **Choosing the Right Visual Form**

The real value of data in academic research depends on how they are communicated and goes far beyond mere collection. Besides concealing important information, misleading visual representations may also mislead the viewer. Consider using a pie chart to show the temperature readings for the last 10 years. Aside from being unclear, this would not explain the nuanced story behind the mysterious discrepancy. On the other hand, the line graph would beautifully and vividly show trends and changes over time as it graphed the ebbing and flowing of the stream. A well-chosen visual format can improve understanding, stimulate thought-provoking conversations, and speed up decision-making. Imagine a situation in which the national employment rate is only reported as a

gross spread by the Statistical Service, then most people would not understand the resulting economic impact. However, consider a bar graph showing the deviations from the average from year to year of the average denomination. It would immediately show whether the economy is doing well or struggling. Every scientist must develop the skills of persuasion to effectively transform the landscape of spirituality.

## **Conclusion**

A valuable skill for aspiring academic researchers worldwide is mastering the complex and subtle art of selecting the best visual representations for different data types and scales. For example, listening to the qualitative accounts of experienced fishermen, who tell vivid stories of their experiences at sea, it is crucial to understand the essence of their stories through careful visualisation that reflects the feelings they express. Similarly, when analysing quantitative metrics, it is important to select visual aids that will successfully convey trends and patterns in order to demonstrate the volatility of cocoa exports. Researchers can ensure that their findings are not only presented truthfully, but also interpreted in a way that engages their audience and encourages deeper understanding and discussion by gaining a strong understanding of the data visualisation techniques. Their research will ultimately be more educational, interesting and relevant if they focus on clarity and context.

## Chapter 3: Principles of effective data visualisation

Data visualisation is a bridge that turns complex, often intimidating, data sets into understandable, engaging visual narratives in the ever-changing world of academia. Through this process, many numbers and figures are converted into visually attractive content, which makes the complicated concepts easier to understand. Effective visualisation helps researchers communicate with their audiences and allows meaningful comparisons to be made.

To make full use of data visualisations, it is important to follow established principles which not only increase the efficiency of visualisations but also guarantee that the ethical standards are met and that they are tailored to the specific needs of the viewer. The three main ideas that are essential for this exercise will be discussed in this chapter. Effective data visualisation relies on simplicity and clarity, which highlight the message through clear language and design, and make the information easy to understand. Honesty and integrity in data presentation are equally critical, which means presenting data accurately without misleading graphics, manipulative scales or missing context to maintain the viewer's trust in the visual narrative.

Last but not least, aesthetics and audience considerations are essential to strike a balance between the attractiveness of the product and its effectiveness. This includes ensuring that elements such as layout, colour and font are carefully selected while respecting the audience's preferences and expectations in order to encourage meaningful participation. In demonstrating these ideas, we will use real-life examples from socio-economic context and from a wide range of academic research. We will show how these concepts are applied in practice and provide insights into best practices for effective data visualization by looking at case studies from various fields, including public health, education and economic development.

## Clarity and Simplicity

The main goal of a data visualization is to communicate information to a viewer in a comprehensible and effective way. Effective visualization should not require lengthy explanations and should be immediately understandable. Well-designed visualisations prioritize simplicity and clarity, allowing viewers to quickly identify important trends and insights, and to facilitate understanding without adding unnecessary ambiguity or distraction. The audience can interact with data in a meaningful way and make decisions based on their understanding of the data, thanks to these visual representations that give the data its life.

### Why Clarity Matters

Consider the presentation by a researcher on the regional average for primary school enrollment. The map displayed on the screen is a breathtaking visual experience for the viewer. Excessive grid lines litter the diagram, making the background chaotic, and vivid, distracting colors compete for the viewer's attention rather than being drawn in. Important insights are also difficult to detect because the view is so many data points crammed into a single visual representation. Prioritising clarity in the presentation of data is essential to enhance understanding and improve communication. This can be achieved by highlighting the most important elements of the registration number and by removing unnecessary details that hinder the viewer from understanding the title. The key messages could be highlighted and the key messages could be effectively absorbed by the audience through a more unified colour scheme and a simpler layout.

### Applying Simplicity

Simplicity is often mistaken for being uninteresting or uncreative, but it is based on a conscious choice to present information clearly and straightforwardly. It is a methodical process, reducing complex concepts to their most basic form, allowing for a presentation that is both impactful and captivating. In addition to having a thorough understanding of the subject, this process requires an artistic sensibility to arrange the components in a way that is both visually appealing and easy to understand. By eliminating unnecessary details, we make it easier for the message to be heard and invite the listener to understand the concepts without being distracted by flowery language or complex reasoning. Consider this example

- ✓ **Use of Appropriate Chart Types:** Instead of using a complex 3D pie chart, a simple bar graph is a much better way of showing the gender balance in secondary school enrollment in the central region. A 3D pie chart with 10 parts, one for each region, would be a less efficient descriptor. This may make comparisons difficult and complicate depiction. A better alternative would be a simplified legend with initials. By showing the male and female enrolment

numbers for each region side by side, this chart format facilitates comparison between the two groups. This strategy allows stakeholders to quickly understand the differences between the regional trends in school enrollment between the sexes, which will lead to better informed discussions and decisions on regional education policies and initiatives.

- ✓ **Limit Colour and Visual Effects:** The choice of a harmonious colour palette is crucial when presenting data, to avoid confusing the audience. For example, a professor can effectively communicate the percentage of students who passed mathematics, science, and English for five years by using a carefully selected colour palette. Mathematics should be represented by a bright blue, science by a cool green, and English by a warm yellow. Apart from improving clarity, this method also engages viewers by allowing them to quickly understand the data and compare trends without unnecessary confusion.
- ✓ **Avoid Overloading with Data:** It is more efficient to focus on the five most important cities to better understand the annual precipitation patterns. Alternatively, cities could be logically grouped using a line chart according to climate or geographic proximity. This method allows more detailed comparison of rainfall data, which makes it easier to identify patterns and variations. We can provide a more complete analysis of rainfall dynamics in these areas by focusing on a smaller area or by carefully organising the data.

Globally, time is often of the essence in the dynamic setting of academic conferences and political debates. In these types of environments, the audience may be attracted by a well-designed visualisation which is simple and visually attractive. Such clarity increases the credibility of the researcher and also allows for faster and more efficient decision-making. The findings are more likely to be taken into account for practical application and implementation if presented in an engaging and easily understandable way. This strategy ensures that relevant information and proposals reach the relevant stakeholders and have a significant impact on practice and policy.

### **Integrity and Honesty in Data Display**

Transparency in data visualization requires careful consideration of ethical considerations. Researchers are strongly encouraged to present data in the most honest and transparent manner possible. Visualizations that are produced in a dishonest manner run the risk of misrepresenting the underlying facts, which may ultimately lead to inaccurate conclusions and poor decision-making. Apart from jeopardizing the veracity of the data provided, distortion erodes the trust of viewers in researchers and their work. Therefore, in order to maintain transparency and respect the ethical principles of communication, visualisations must be done in a way that accurately represent the data and use clear scales, appropriate contexts and objective representations.

## Avoiding Misrepresentation

Integrity is essentially the commitment to provide information in a completely objective way. It means actively avoiding any manipulations that could distort the message, such as exaggerating some details, downplaying others, or changing the facts to make a false statement about a fundamental truth. Thanks to this commitment to transparency, people can make informed decisions based on a strong understanding of the information. Consider this example;

1. **Manipulating Axes:** Consider a careful analysis of global inflation trends. This report shows a graph that shows the inflation rate, but instead of starting at 0%, the y-axis starts at 10%. Such a deliberate choice of scale could create a misleading visual effect in which even small variations in inflation rates appear to be much more perceptible. Viewers may be unnecessarily alarmed and anxious by such a presentation and may misinterpret the data to suggest more serious economic instability than is warranted. The student stresses the value of graphic integrity and the possible consequences of falsifying the economic data in this careful analysis.
2. **Selective Reporting:** The perception of stakeholders may be distorted if the bar graph of cocoa production shows only the years with favourable data and ignores the years with low production. The integrity of the information is jeopardised by this selective presentation which leaves out important details on trends in cocoa production. In order to enable stakeholders to take informed decisions representing the whole industry, a comprehensive overview covering both high and low production years must be provided. Transparency of data is essential to facilitate investment in the sector and strategic planning.
3. **Honest Labelling:** Making sure that all labels, legends, and footnotes in the reports of university researchers are accurate and identifiable is essential when presenting their findings on the impact of free education policies on students' academic performance. By paying close attention to details, one can avoid unexpected results from relationships between variables that may not be supported by the data. For example, the researcher should explain each data point thoroughly and ensure that any correlations made are supported by evidence when showing the trend in student performance. Moreover, a distinction between causation and correlation is essential to preserve the integrity of research findings. Researchers can help develop a more accurate and reliable understanding of how this policy affects student performance by implementing these practices.

Integrity of data reporting is a high priority for the Ghanaian academic community, which operates in a dynamic and competitive environment where in-depth research has a significant impact on government decision-making and policy-making. In addition to

enhancing the professional reputation of the person, truthful and open communication promotes a critical sense of confidence among researchers and the public they serve. But, regardless of the intended outcome, any kind of misleading data visualisation can seriously undermine the credibility that has been painstakingly cultivated over years of dedication and hard work. This distortion of trust among stakeholders can damage future cooperation, threaten confidentiality and discourage creative projects. The implications are profound because the integrity and clarity of our data are a crucial element of accuracy and a cornerstone of trust in an academic context that relies primarily on ethical standards and transparent analysis. Researchers and academics therefore, need to maintain the highest standards of presentation to maintain their credibility and make a positive contribution to society.

### **Aesthetics and Audience Consideration**

The effectiveness of data visualisations is strongly influenced by aesthetic appeal and consideration of audience preferences. In addition to being accurate and reliable in conveying information, visual representations must also be relevant and relevant to the particular audience to which they are addressed. Creators can add a unique experience by considering elements such as colour schemes, layout concepts, and the emotional impact of images. This deliberate strategy ensures that the data is not only understandable but also relatable and convincing, which strengthens the link between the audience and the information being presented.

### **Balancing Beauty and Function**

Apart from being decorative, attractive visualisations engage the audience and facilitate understanding of the information displayed. The overall design is improved by the thoughtful choice of a single colour scheme, leaving plenty of room to avoid smudges, and the use of legible typography. Moreover, a well-organised layout ensures continued attention and effective communication of information by smoothly guiding the viewer through the content. From raw data, a powerful narrative that resonates with the audience can be created by thoughtful design decisions. Consider this example.

1. **Colour Use:** In a detailed analysis of malaria cases, different shades of green, a colour associated with health and vitality, could be used to differentiate between districts. Apart from improving clarity, such a distinctive colour scheme would encourage a positive impression of the charitable contribution. Red flags could be used sparingly to draw attention to specific areas requiring urgent attention or where the spread of malaria is more pronounced. Strategic use of red would help to highlight the important areas and quickly identify those in need of support and specialised resources.

2. **Typography:** Transparency and legibility should be your top priority when choosing a font for your scholarly publications. Fonts such as Arial and Calibri are strongly recommended because of their legibility and clear qualities that enhance understanding by the audience. For example, selecting a neat and professional font is crucial when presenting data on youth unemployment in a country. By making these choices, the emphasis is kept on the importance of the information and insights to be shared, rather than being distracted by ornamented or complicated fonts, which may obscure the message and reduce the overall impact of the presentation. The researcher can effectively engage the audience and present their findings with greater accuracy and credibility by using clear fonts.
3. **Consistent Layouts:** In order to ensure consistency and clarity, it is essential to maintain the scales, chart sizes and legends used to depict the different visualisations in the report on a country's GDP growth over the last 10 years. Consistent chart dimensions make it easy for readers to compare data displayed in different formats. The standardisation of the scale makes it possible to interpret clearly trends and shifts in GDP growth, and confusion can be avoided by ensuring that legends are similarly formatted. This attention to detail enhances the professionalism of the report and helps to create a more convincing narrative of economic performance over time.

## Understanding the Audience

Transparency is one of the basic principles of effective data visualisation, and Transparency is about knowing your audience. The design, complexity and presentation of the visualisation should always be adapted to the specific needs, expectations and expertise of the users. Inappropriate or overly complex visualisations can confuse or antagonise viewers, whereas well-targeted visualisations enhance understanding, engagement and decision-making. In the research, policy and community development areas where data-driven advocacy and policy making are on the increase, the ability to present information clearly and convincingly to various stakeholder groups is invaluable. Different audiences require different approaches to communicating messages. The context in which data are shared - whether at a government policy meeting, an academic conference, or a community durbar - strongly influences the choice of visualisation techniques. Below are examples of how the visualisation of the data can be adapted to suit three different audiences:

- ✓ **Policy Makers:** Policy makers typically need clear, concise and actionable information to support their decision making. Transparency should be prioritised in meetings with high-level stakeholders, such as those organised by the Ministry of Education, to ensure clarity, brevity and immediacy. Dashboards, infographics and scatter charts highlighting key performance indicators (KPIs), such as school enrolment rates, teacher distribution, pupil-to-teacher ratios and



infrastructure deficits in different regions, are particularly effective. For example, a policy briefing on basic pedagogical infrastructure could include a dashboard that combines bar charts, heat maps and proportionate symbols to illustrate geographical differences in pedagogical facilities. Visual elements should be annotated with brief captions and use a uniform colour scheme to distinguish between regions or priority indicators. Avoid over-technical language and complicated statistical schemes in this context - policymakers are more interested in the statistical 'what' and 'where' than the statistical 'how'.

- ✓ **Academic Colleagues:** Expectations change when presenting data to an academic audience, for example, at a faculty seminar at a university for development studies or at an international research conference. Here, the audience often has a higher level of statistical literacy and is interested in methodological rigour, analytical nuance and theoretical implications. This setting allows for more detailed and sophisticated visualisation. Scattering plots with regression lines, confidence intervals, box plots, and multivariate graphs can efficiently convey complex relationships and statistical trends. For example, a study looking at the relationship between household income and the school retention rate of adolescents could include a scatter plot with a regression line, together with a histogram showing the distribution of income levels. Data showing error margins, p-values, or effect sizes are also useful in academia, as they lend credibility and transparency to the results.
- ✓ **Community Groups:** Community groups require visual representations that are easily understood, culturally appropriate and free of jargon, as they are often composed of people with different levels of formal education and little experience with statistical graphics. The data should be presented in clear and attractive formats at community-based stakeholder meetings, such as those organised in fisheries communities such as Elmina and Ada. For example, familiar symbols such as fish icons for the amount of yield and the use of bright and bold colours for the years could enhance the bar graph showing the changes in the yield of fishing over five years. Annotations should preferably be in the dominant local language, and the images should avoid jargon that might alienate non-specialists. This approach ensures that community members not only receive information, but can interpret, discuss and use it to inform local action or advocacy.

Globally, where research increasingly shapes policy-making, donor investments, and public discourse, the success of a project often depends on how well its data is communicated. A well-designed, audience-appropriate visualisation ensures that the message behind the numbers is not lost, misunderstood, or disregarded. For instance, the presentation of maternal health data to the Ministry of Health might focus on regional disparities and intervention coverage rates, while the same data shared with community health volunteers in Twifo Praso would use pictograms and storyboards to highlight prenatal care attendance trends in relatable ways. By tailoring visualisations to suit specific audiences, researchers and practitioners not only enhance comprehension but also increase the chances of their recommendations being heard, valued, and acted upon.

They do so by bridging the often-discussed research-business divide, which promotes socially inclusive development and evidence-based management.

## **Conclusion**

In conclusion, academic data visualisation requires adherence to the fundamental values of simplicity and clarity, honesty and integrity, as well as aesthetics and audience considerations. These rules guarantee that the data visualisations are clear, convey the essential information and remain accessible to a wide range of users. Following these guidelines will increase the calibre and legitimacy of academic output for researchers. In addition to promoting openness and trust in the academic community, this will also protect the integrity of research findings and reduce the risk of misinterpretation and manipulation. Moreover, good data visualisation translates uninterpreted data into clear understandings that can guide policy, stimulate debate and help in making evidence-based decisions. By presenting data in visually attractive and relatable formats, well-designed visualisations engage the audience and help bridge the gap between the complexity of research and the practical applications in the real world. The adoption of these guidelines on data visualisation will benefit academics and policymakers by strengthening the link between research and societal impact and ultimately promoting academic advancement, public debate and national development.

# Chapter 4: Tools and software for data visualisation

## Introduction

Presentation of findings in a clear manner through effective data visualization is more important than ever in today's academic research landscape. The days when researchers presented their findings in the form of text, tables, and basic static charts are long gone. To uncover patterns, trends, and relationships hidden in vast sets of data, modern data visualization turns raw numbers into clear, interactive, and captivating visual representations. Researchers in fields such as education, health, environmental studies, economics and social sciences are increasingly using digital tools worldwide to streamline, improve and professionalise their data reporting. From simple bar charts in Microsoft Excel to interactive dashboards in Tableau, these tools allow you to explain complicated information in a way that even non-professionals can understand. This chapter looks at a number of widely used data visualisation tools available to researchers, highlighting their features, benefits and applications in academic research. This chapter will give you useful advice on how to choose and use the best research tools for your needs, regardless of your level of experience as a student, postgraduate student or researcher.

## Microsoft Excel

Microsoft Excel is the most popular and widely used data visualisation tool among researchers. It is part of the Microsoft Office suite, which is installed on almost all computers in universities, government offices and many private organisations. Although often considered a simple spreadsheet program, Excel offers several visualisation features that are very powerful for small to medium-sized datasets.

## Key Features and Capabilities of Excel for Data Visualisation

Microsoft Excel is one of the most popular programs for analysing and visualising data in scholarly research. It is a useful tool for new researchers, students and professionals

because of its adaptability, accessibility and user-friendliness. This section explains the basic features and capabilities of Excel, which help researchers organise, analyse, and visually present their data efficiently. Each element is explained in simple terms, and practical examples are given to show how it can be applied to real-life research scenarios, particularly in academia.

## 1. Charts and Graphs

One of the most valuable features of Excel is its ability to transform numeric data into visual representations. Graphics and charts help readers and researchers quickly understand trends, patterns, and comparisons in the data set. Excel offers several basic and advanced chart types that are appropriate for various data visualisation needs.

### Types of Charts and Their Uses

- ✓ **Bar Charts:** Bar charts are one of the most powerful tools for comparing quantities across different categories in a visualisation of a waterfall. They use rectangular bars whose length corresponds to the thickness of the legend. This allows viewers to quickly compare and interpret differences between different themes recommend another theme. Depending on the nature of the data and the preferences of the researcher, the toolbar charts may be displayed vertically or horizontally. They are widely used in academic research, business intelligence and public health studies, among other areas, to present categorical data in a clear and visually attractive way. For example, a student of PE at Winnebago University could undertake a study to collect data on the number of male and female participants in interschool sports competitions in the central region. In this case, a bar graph would be a suitable tool for visually comparing the rates of participation of the two sexes. The diagram would show two bars, one for the male participants and one for the female participants. The length of the bars would indicate the number of people in each group. Both readers and researchers will be able to quickly identify trends, gaps and patterns in data with this simple visual representation.
- ✓ **Line Graphs:** Effective tools for showing trends in data over time, line charts are perfect for showing changes that occur over days, months, years, or even longer periods of time. These charts make it easy for viewers to see patterns, trends, and changes in data by using points connected by straight lines to show how variables change. Line charts are often used in academic research and reporting to visualize data in areas such as education, health, economics, and social sciences, where tracking progress or decline over time is critical. They are particularly useful for allowing rapid comparisons over time, which helps a wide range of people to access and understand complex data. For example, a researcher looking at the trend in senior high school enrolment between 2020 and 2025 could use a line graph to show how enrolment has increased or decreased over the five years. To illustrate the increase or decrease in enrolment, the data points from each year would be plotted on the graph and crossed out. Policymakers, educators and other stakeholders would be better able to assess

the effectiveness of education policies, identify important changes and make plausible decisions with this visual representation. In addition, the data analysis process can be improved by comparing enrollment trends for different regions, schools, or gender categories using multiple line graphs within a single graph.

- ✓ **Pie Charts:** Pie charts are a popular and aesthetically pleasing way of showing the division of a theme into separate themes. Each slice of the circular chart used to display the data represents a part of the total amount of the category. Visual comparison of different slices is simplified by the fact that the size of each slice corresponds to the amount or percentage of the average. Graphs allow users to quickly understand the overall distribution of values and are particularly useful for displaying the proportions, percentages, and relative sizes of data in a dataset. In order to keep information clear and avoid confusion, they work best when they work with a small number of categories, usually no more than five or six. For example, a student investigating absenteeism at primary school could collect information on factors such as illness, family responsibilities, financial burdens, transportation problems, and other private issues. The student could effectively display this information by displaying the percentage of absences attributed to each cause on a pie chart. Apart from making the data easier to access, this visual representation would help educators, school administrators and policy makers to identify the root causes of absenteeism. By examining the map, they could determine which interventions should be prioritised to address the main issues affecting school attendance.
- ✓ **Area Charts:** Area charts are a type of data visualization that resembles line charts, but differs in that it uses shading or color to fill in the space below the line. This design choice highlights the size of the values over time, which makes it easier to compare the values and the trend over time. When you want to visualize multiple data sets stacked together to show the overall trend and size, or when you want to show how individual data points add up to a cumulative total, area charts are particularly useful. In data sets where the primary variable is time or sequence, they can successfully highlight increases and decreases, trends and changes. For example, an area diagram could be used by an agricultural scientist examining monthly cassava and maize yields to graphically show the total yield for the whole growing season. A researcher can quickly determine which crop contributes more to the total yield at each stage of the season by plotting the two crops together. The area map can also show differences in profitability of crops, harvesting times and rainfall patterns. This makes it a useful tool for practical decisions taken by farmers, policy makers and extension staff to improve food security and maximise resource allocation beyond academic research.
- ✓ **Scatter Plots:** The basic graphical tools for visualizing the correlation or relationship between two quantitative variables are scatter plots. Scattering plots provide a simple way of seeing patterns, trends, and clusters in a data set by arranging data points on a two-dimensional graph with one variable on the x-axis and another on the y-axis. They help to determine whether there is no apparent correlation (the variables do not appear to be related), a negative correlation (one variable rises while another one falls) or a positive correlation

(the two variables rise together). Scattering charts can not only show correlation, but also alert anomalies or unusual findings that may require further investigation. This makes them essential for analysing experimental data and formulating hypotheses in areas such as social research, health sciences and education. Imagine a student who wants to investigate the relationship between a student's overall physical ability and the time he spends in physical education. Researchers can visually evaluate whether more Physical Education time is correlated with higher levels of fitness by creating a scatter plot comparing the fitness score of each student with the number of PE classes they attend. A positive correlation is seen when the points go up from left to right, suggesting that fitness may increase with more frequent physical exercise. On the other hand, a random distribution of points indicates no correlation, whereas a decreasing trend suggests a negative correlation. Such visual data can help educators to target interventions that will successfully improve student health outcomes, guide further statistical analysis and inform curriculum design.

## **2. Pivot Charts**

Pivot charts are powerful interactive visualization tools that facilitate the quick summarisation, analysis and presentation of complex data. It allows users to dynamically rearrange and organize data without changing the source, because it is built directly from a PivotTable. This flexibility will be particularly useful for professionals and academic researchers who deal with large amounts of data from many different variables. For example, a student who is looking at absenteeism can use a pivot chart to visualize the overall absenteeism rate, compare regional differences, filter data by year, and explore trends between public and private schools with a few clicks. This dynamic interaction improves the ability of users to detect trends and make informed deductions quickly. Pivot charts facilitate complex analytical functions such as drilling, filtering, and slicing for more detailed insights than a simple summary. They also work well with other Excel features such as timelines and slicers, giving users even more control over how the data is displayed. In addition, the diagram can be adapted to different diagram styles, such as pie charts, line charts, and column charts. simplify the terminology and presentation. Because of their versatility, they are essential for business intelligence, academic research and decision-making processes that require interactive, short and clear visualisations. Crossover charts simplify data analysis, save time and increase the impact and clarity of institutional reports or research papers.

### **Advantages of Pivot Charts**

Pivot charts are powerful tools for facilitating the quick understanding and visualization of topics. They are particularly useful when dealing with complicated data sets or large volumes of data. Below we will look at some of the main benefits of using pivot tables in your data-analysis work. Fast and easy data summarisation: One of the main advantages of pivot charts is that they allow users to quickly and easily assemble large sets of data that would otherwise be difficult and time-consuming to analyse. Pivot charts automatically group and calculate key metrics, sparing you the trouble of manually

sorting through thousands of rows of data. For example, without using complicated formulas, sales data for the entire year can be sorted by month, quarter, or region. Users can focus more on insights than on data preparation, which also makes data analysis more efficient.

Moreover, pivot charts, by eliminating the need for manual calculations, offer immediate calculation such as totals, averages and totals, which further increase efficiency. The main trends, patterns and outliers in the data set are briefly and represented visually in this real-time summary. Pivot charts therefore turn complex data into simple information, empowering users to make more rapid decisions. They are a vital tool for professionals who want to increase productivity and improve business intelligence, because they are adaptable to different sectors and use cases. Interactive analysis through data filtering and sorting: due to their highly interactive nature, pivot charts offer a significant advantage over standard static charts.

Pivot charts allow users to drill, filter, and sort their data directly within the chart, unlike traditional charts, which display a static view. Thanks to this interactivity, you can explore your data from several angles without having to distort the message. When analysing sales data for different regions, it is easy, for example, to drill down into specific segments to see the most important data, sort the data to highlight the top sales items or top month, and filter the chart to focus on a particular region's performance.

Due to their adaptability, pivot charts are an effective tool for complex matrix analysis. The ability to manipulate data directly from the spreadsheet also makes prioritization easier. prioritize the spreadsheet. Instead of working with raw data, users can interact with visual assets to find trends, identify anomalies, and gain deeper insights. Clearer reporting and better support for business strategies is facilitated by the smooth integration of data collection and visualization.

Pivot charts are essential for anyone who wants to make smart data-driven decisions, as they are useful not only in business, but also in academic research, financial analysis, and other fields that require a detailed but easy interpretation of the data.

Pivot charts are powerful tools designed especially for the effective management and visualization of large datasets. Pivot charts use sophisticated data processing techniques to quickly summarize complex information, unlike traditional charts, which may be laborious and slow to process thousands or millions of lines.

They are ideal for large-scale business, research and data analysis scenarios because of their efficiency, which allows you to explore and analyse even large data sets without taxing your computer or software. Aside from being efficient at processing data, pivot charts also have dynamic features such as automatic recalculations. This saves time and reduces manual labor, because the pivot chart updates its summary and visualizations instantly whenever new data are added or data sources are modified.

Scalability allows users to work with datasets of varying sizes while maintaining visual clarity and useful information. Because of their versatility, pivot charts are an invaluable tool for analysing data and making decisions across a variety of disciplines.

### **3. Conditional Formatting**

Researchers can automatically apply visual indicators to cells based on their values using conditional formatting, a powerful tool for data visualization. This property, without requiring manual inspection, helps to identify quickly patterns, trends and outliers in data sets. These visual cues help users focus on important information and to effectively interpret large amounts of data, which improves analysis and decision-making.

Some basic components of conditional formatting are named after saints. Color scales help you to identify extremes by applying gradients to the cells to represent different values. For example, the word martyrdom is used for high values, and the word martyrdom for low values. The data bars visually show the size or rank of the data points in relation to each other by adding horizontal bars within the column. Icon sets provide a quick understanding of complex data conditions by using symbols such as arrows, signs, or flags to indicate categories, levels of performance, or direction changes.

Conditional formatting can be applied in different ways in practice. To help stakeholders identify areas of need, a public health researcher studying teenage pregnancy rates in the Eastern region could, for example, use a red scale to highlight the districts with the highest teenage pregnancy rates. In a similar way, a PE teacher could use the red stamp to identify students who score lower than the average, so that they can be quickly identified as needing more help.

To facilitate budgeting, researchers in the financial sector can use icons or data bars to show expenditure that is exceeding the budgeted amount. Considering all the above, conditional formatting increases the availability of data and facilitates rapid, data-driven decision-making in a wide range of academic and professional settings.

### **Why These Features Matter in Academic Research**

Researchers can convert raw data into formats that are easy to understand using Excel's data visualization tools. By presenting information graphically, these tools facilitate the interpretation of large, complex datasets and help researchers quickly identify important trends and insights. Excel helps you to understand research findings more comprehensively and reduces confusion by simplifying the presentation of data, which is essential both in the workplace and in academia. Excel visual tools such as conditional formatting, pivot tables, and bar charts help researchers present their findings in a more clear and convincing way. These characteristics facilitate the rapid identification of patterns, connections and anomalies, which improves the efficiency and clarity of the analysis process. Acquiring competence in these areas improves the reporting and presentation and makes the conclusions more palatable to different audiences, irrespective of the level of experience of the researcher. Moreover, the visualization



capabilities of Excel are essential to support evidence-based decision making in a wide range of areas. These resources are essential for researchers in Ghana and worldwide to support public health initiatives, improve pedagogical strategies, inform policy development and contribute to academic discourse. Excel's capabilities allow researchers to generate insightful findings that support strategies for solving problems in the real world, as well as advance academic knowledge.

Summary of Key Features and Their Relevance

Feature	Purpose	Example in Research
Bar Charts	Compare quantities across categories	Compare male and female participation in sports events
Line Graphs	Show trends over time	Track student enrolment trends over several academic years
Pie Charts	Display proportions of a whole	Show the causes of absenteeism in a school
Area Charts	Emphasise total values over time	Display cumulative harvest yields during farming seasons
Scatter Plots	Reveal relationships or correlations between variables	Examine the relationship between study time and examination scores
Pivot Charts	Summarise and visualise large datasets	Compare teacher absenteeism rates by district and term
Conditional Formatting	Highlight data patterns, trends, or anomalies.	Identify districts with the highest teenage pregnancy rates using colour scales.

Why Use Excel?

Microsoft Excel is a widely used and affordable tool for data analysis and visualization, particularly in academia and in professional settings. Its availability and user-friendly interface, which allow professionals, researchers and students to create simple yet powerful visualisations without specialised training, is one of the main factors contributing to its widespread use. Microsoft Excel is an easily accessible tool to work with data, as it is already installed as part of the standard software packages of many institutions, including government offices, universities and schools. Excel also makes it easy to seamlessly integrate your report with your program. Adding tables, graphs, and charts to your academic reports and presentations is easy with Microsoft Office products

such as Word and PowerPoint. Researchers and students who often have to prepare documents and presentations for seminars, conferences, and lectures benefit from this workflow. Effective communication of research findings and concepts is supported by the easy conversion of Excel data visualizations into Word documents or PowerPoint presentations, which ensure that the information is presented in a professional and clear manner.

## **SPSS, R, and Python**

As research becomes more data-driven, the need for tools that can manage large data sets and perform sophisticated statistical analyses is increasing. Recommended options for researchers working on projects requiring more than simple visualizations are SPSS, R and Python.

### **SPSS (Statistical Package for Social Sciences)**

The popular statistical program SPSS is renowned for its strong analytical capabilities and ease of use. It is particularly popular with post-graduate students, teachers and researchers, particularly in fields such as education, health and social sciences. One of the main factors contributing to its popularity is its intuitive point-and-click interface, which allows users to perform sophisticated data analysis without having to write code. Because of its availability, it is a perfect tool for researchers who need robust statistical functions but lack sufficient programming skills. Among the software's many features is a wide range of plotting options, including historical, box, scatter, and bar plots. These visualization tools help users to effectively interpret and present their data. In addition, SPSS offers powerful data management tools to help users work with complex data sets by facilitating data cleaning, data manipulation and advanced statistical analysis. It is a flexible tool for both academic and applied research thanks to its integrated functions that support tasks ranging from simple descriptive statistics to complex probabilistic analysis. The SPSS is a crucial tool for quality and decision-making process of research. For example, a researcher could use SPSS to analyze and compare academic performance trends between urban and rural students by using box plots and clustered bar graphs to show the differences clearly. Similarly, a public health researcher could visualize the prevalence of malaria in an area using SPSS, using line charts or histograms to identify trends and guide policy interventions. The versatility of the software in meeting the diverse requirements of research underlines its importance as a tool.

### **Advantages**

Even people who are not familiar with statistics and data analysis can benefit from this tool because of its easy user interface and low learning curve. Because it is easy to integrate with Microsoft Office products such as Word and Excel, users can create reports and presentations faster and integrate statistical outputs easily into their spreadsheets and documents. This feature is particularly useful in academic and professional environments where results need to be clearly communicated. In addition, the instrument includes a variety of statistical techniques, including descriptive statistics

(e.g. A. abstract statistics, such as regression analysis and hypothesis testing, with metrics of trend and variability. It is suitable for a number of research requirements because of its adaptability, including data collection and the assignment of population characteristics from sample data. This instrument is a good choice for students, teachers and statisticians as it strikes a useful balance between robust functionality and ease of use.

## **R**

R is a flexible, open source and free programming language designed especially for graphics and parallelism. Its powerful capabilities in data analysis and visualization have made it popular in the field of comparative medicine. One of its most notable features is its extensive ecosystem of packages, which allow users to create highly editable, professional-grade graphics. R is a toolkit for many fields and is appreciated by researchers not only for its sophisticated statistical tools but also for its adaptability to handling complex data sets and creating perceptual visual representations. R is increasingly used in brainstorming and in other research areas. For example, Tamale environmental scientists could use R to create heat maps showing rainfall trends over a 10-year period, which would help in agricultural planning and climate studies. In the same vein, social scientists can use R to visualize survey data on important social issues, such as youth unemployment, and use user-friendly pie charts to improve data interpretation and policy debate. In addition to these cases, Ghana and other developing countries, where financial constraints often prevent access to expensive statistical software, have benefited greatly from the availability of R as free open-source software. The democratisation of robust data analysis supports the development of the spiritual profession and evidence-based decision-making.

### **Advantages and Disadvantages**

Strong, free, and incredibly customizable tools for data analysis, R and Python are particularly suited to handling large, complex data sets. Because of their open nature, users can access a wide variety of repositories and libraries, tailored to different analytic needs. They also benefit from strong online communities and a large library of educational material, such as forums, tutorials and documentation, which help users to solve problems and develop skills. This makes them particularly attractive to researchers and data scientists who want to perform sophisticated analyses without having to pay for expensive software licenses. However, there is a downside to the benefits. Basic programming skills are required for both R and Python, which may be an obstacle for newcomers or users used to more user-friendly spreadsheet-oriented programs such as Excel and SPSS. Because of their more difficult learning curve, specialization requires time and effort to acquire. Users also need to install software and sometimes have to deal with technical problems such as package dependencies or compatibility issues that may require specialized knowledge to solve. Notwithstanding these challenges, the adaptability and power of these tools make them indispensable for in-depth data mining in both academic and professional settings.

## **Python**

Like R, Python is a free and open-source programming language known for its ease of use, versatility, and power in data analysis and visualization. Thanks to its large library and ease of integration with other tools, it is particularly popular in the areas of data science, machine learning and web development. Python is a flexible option for professionals and students who need to analyze and present complex data sets in a clear and concise way, because it supports both static and interactive visualization with strong libraries. The practical applications of Python in a wide variety of industries demonstrate its versatility. For example, a data science student could use Python to create interactive line graphs showing trends in the COVID-19 cases by region, which provide key data for monitoring public health. Similarly, to improve malaria surveillance and allow for real-time monitoring and decision-making, an epidemiologist could use Plotly to create an interactive dashboard. The versatility of Python helps not only the health sector, but also other sectors such as finance, agriculture and education. This will allow data-driven strategies and innovation.

## **Advantages and Disadvantages**

Software has significant advantages because it is open source and free, which makes it extremely accessible to users without incurring prohibitive costs. It is suitable for novice and advanced users alike, as it is sufficiently adaptable to handle a wide range of visualizations, from simple, straightforward graphics to complex, layered graphics. It also has a large and supportive user base, especially in the fast-growing technology sector, where users actively exchange resources, guides and solutions to support teamwork and creativity. However, there are problems to be solved. Programming skills are essential for the effective use of this software, which could be a barrier for non-programmers. As learning the instrument requires time and patience, beginners may find the learning curve steep. With commitment, users can use the software's robust features to create high quality visualizations despite these early problems. Increased focus on technical education and community support can help to mitigate these problems and promote wider adoption and skills development.

## **Tableau**

Tableau is particularly known for its user-friendly drag-and-drop interface, which allows users to connect to a variety of data sources and create powerful visual narratives and screens. Due to its versatility, it is very useful for professionals in a wide range of sectors, including academic researchers and business analysts, as it allows for a more informed presentation and exploration of data. Public sector and development work may find the Tableau capabilities particularly valuable. For example, a public health officer could use Tableau to create tables showing the prevalence of malaria in different districts and age groups to more efficiently target interventions and identify hotspots. In a similar vein, education policy analysts could use the Tableau to track and explore regional and gender-specific school enrolment trends, and to help in data-driven decisions to improve equity and access to education. In addition to these cases, Tableau dynamic visualisations

facilitate evidence-based policy making, monitoring of programmes and communication between stakeholders in the international field.

### **Advantages and Disadvantages**

This instrument has many notable benefits, especially for researchers and students. One of its main advantages is its intuitive design, which allows it to be used by people with no programming experience. It also facilitates efficient analysis of complex and large data by supporting large data collections. The fact that academic users can use the license free of charge reduces financial barriers and encourages widespread use in research and education.

However, there are challenges to remission. Because the software requires a lot of processing power, it may not run on older or less powerful computers. Without academic discounts, professionals and organisations with limited financial means may find the cost prohibitive. Moreover, because cloud sharing capabilities depend on it, users in isolated or rural areas with erratic or limited internet access may find it difficult to collaborate with others and access data easily. In order to increase the applicability of the instrument in a wide range of situations, in particular in areas with limited infrastructure, it is necessary to address these constraints.

### **Microsoft Power BI**

Numerous applications of Power BI increase the value of the tool in the area of effective planning and management. For example, it can be used by university administrators to analyse enrollment trends by academic year, programme and gender to identify trends and guide policy decisions. Similarly, district hospital administrators can monitor important performance metrics such as patient wait times, resource use and treatment outcomes in real time, allowing for a more responsive healthcare delivery. In addition to these, the availability and scalability of Power BI make it a valuable tool for many sectors, such as public administration, finance and agriculture, where data visualization promotes efficiency, transparency and strategic expansion.

### **Advantages and Disadvantages**

Given its advantages, this instrument is very attractive for organisations searching for scalable and affordable solutions. Because it is accessible, even organisations with tight budgets can implement it without facing significant financial pressure. In addition, users can work in familiar environments and workflow efficiency is enhanced by seamless integration with Office 365 and Microsoft Excel. The user-friendly interface removes the need for extensive navigation by allowing even those with little technical knowledge to navigate and use the basic functions efficiently. Despite these advantages, there are significant obstacles to combating piracy. Strong and consistent internet access is essential for the full functioning of the instrument and could be a barrier in places where connectivity is poor. Moreover, although the basic use is simple, specialised training is required to access more advanced features, which may take more time and money for

the institution. Unless this training requirement is adequately addressed, adoption may be delayed and overall productivity may suffer. Considering all of these considerations, successful implementation and maximisation of the potential of the instrument require a balance between these benefits and disadvantages.

## **Conclusion**

The type and volume of data, the specific objectives of the research and the level of technical expertise of the user are some of the important variables influencing the choice of data visualization tool. Microsoft Excel provides an easy and accessible introduction to data visualization for inexperienced researchers, allowing them to quickly and easily create simple charts and graphs. Software such as SPSS, which is particularly useful for social research, strikes a balance between usability and sophisticated analytical capabilities as research needs evolve. Although they require advanced coding skills, programming languages such as R and Python are powerful open-source choices that facilitate complex visualization. Tools such as Tableau and Power BI have also increased their popularity in producing interactive dashboards and real-time data reporting that support a dynamic research environment. By mastering these visualization tools, researchers can transform unstructured data into clear knowledge that can guide evidence-based policy, advance scientific research and advance national development goals. Although many start with basic visualisations such as Excel bar charts, there is much scope for sophisticated interactive dashboards, particularly in important areas such as social policy, education, health and agriculture. This refined visualization capability will ultimately support innovation and sustainable development by facilitating better decision-making and resource allocation, in addition to improving communication on research. In order to maximise the impact of data-driven initiatives at national level and to strengthen the research ecosystem, it is essential to invest in developing the skills to use these tools.

# Chapter 5: Visualising data in academic research papers

## Introduction

Data visualisation is not just a decorative tool in the complex world of academic research; it is a fundamental tool that influences how findings are presented, interpreted and used. Effective presentation of complex statistics can turn them into gripping stories that can influence academic debate, spur policy change, and guide policy initiatives by new researchers and elsewhere. In addition to guiding how to follow generally accepted presentation styles such as APA, MLA, and Chicago, this chapter explores the ethical guidelines that should guide any attempt at data visualisation and explores the strategic use of numbers, tables, and graphs in academic writing.

## Figures, Tables, and Charts in Academic Writing

### 1. Figures

Any visual representation which is not a table, such as charts, pictures, maps, and diagrams, is referred to as a cataloguing number. In academic papers, figures are required to illustrate relationships, trends, and patterns that may be overlooked in the text. For example, a line graph could be used to illustrate the annual increase and decrease in malaria cases reported in the research paper on the evolution of malaria cases over the last 10 years. This visual representation communicates the change in time in a way that a list of numbers cannot. Uniform numbering of figures is required (fig. 1, fig. 2, etc.) and provide a brief and comprehensible caption below the figure explaining its source and content.

### 2. Tables

In order to facilitate value and category comparison, tables are grids that present data in rows and columns. They are particularly useful for presenting precise values, descriptive statistics or summarising survey respondents' replies. For example, in the study of the students' perception of the free SHS policy, a table could be used to summarise the

percentage of positive, neutral, and negative responses in each school. Each table should be numbered (Table 1, Table 2, etc.), have a descriptive name above it and, where appropriate, explanatory notes below it.

Table 1: Students' perception of the free SHS policy

School	Positive (%)	Neutral (%)	Negative (%)
Jukwa SHTS	65	20	15
Hemang SHTS	70	18	12
Oguaa SHTS	60	22	18

3. Charts

Charts such as bar charts, pie charts and histograms are popular for displaying categorical data and percentages. Their visual appeal makes them ideal for summarising results and illustrating proportions in a readable manner. A pie chart could be used to show the proportion of men and women participating in the Twifo Hemang study examining attitudes towards digital health services. A well-selected graph can save the reader from having to sift through paragraphs of text and offers a snapshot of your findings that is both convincing and easy to understand.

APA, MLA, and Chicago Presentation Styles

Proper formatting of your images is as important as the images themselves. Different academic disciplines and institutions have different citation styles. Here is how to incorporate numbers, tables, and graphs into your academic work using the three most common formats.

1. APA Style (American Psychological Association)

Widely used in the social sciences, APA style emphasises clarity and precision.

Key Rules

- 1. Figures and tables are numbered separately (Figure 1, Table 1, etc.).
- 2. The title of a table appears above the table, while the title of a figure appears below it.
- 3. Include a note beneath if necessary to explain abbreviations or sources.

2. MLA Style (Modern Language Association)

Common in the humanities, MLA has slightly different conventions.

Key Rules



1. Label figures and tables as 'Figure' and 'Table,' followed by an Arabic numeral.
2. Provide a caption directly below the figure or table.
3. Cite the source information in the caption.

### **3. Chicago Style**

Chicago style is often used in history and some social sciences.

#### **Key Rules**

1. Number figures and tables consecutively.
2. Provide a descriptive caption below figures and above tables.
3. Footnotes or endnotes are typically used for source citations.

### **Ethical Considerations in Data Presentation**

While visuals can enhance a paper's impact, they can also mislead if improperly used. Ethical data visualisation upholds honesty, transparency, and respect for research participants and readers.

#### **Key Principles**

- 1. Accuracy:** Ensure figures, tables, and charts accurately reflect your data. Avoid distorting scales or selectively presenting data to support a biased argument. For example, in a study examining unemployment rates, manipulating the Y-axis scale to exaggerate differences between variables is unethical.
- 2. Transparency:** State data sources, acknowledge limitations, and explain methodologies. If data were collected through online surveys in Kumasi, specify this in your captions and notes.
- 3. Anonymity and Confidentiality:** Any visual information that might unintentionally identify participants without their consent should be excluded from studies involving human subjects. For instance, it would be unethical to use patient faces in a figure in a health study without the patients' express consent.
- 4. Cultural Sensitivity:** Both the audience and the subjects' cultural contexts should be represented in the visuals. For example, when displaying data about rural communities, refrain from using stereotyped icons or symbols.

### **Conclusion**

Any researcher should become proficient in the art of data visualisation in academic research papers. Tables, graphs, and figures are more than just ornamentation; they are effective instruments that breathe life into your data and make your conclusions understandable, compelling, and useful. In addition to improving the calibre of your research, you will also responsibly contribute to the scholarly conversation and globally by adhering to accepted presentation styles like APA, MLA, and Chicago and by maintaining ethical standards for data visualisation. When you start your research career, keep in mind that occasionally, a well-crafted diagram or meticulously organised table can convey more information than a thousand words. Let your data tell the important story by using these tools sensibly and morally.

# Chapter 6: Case examples of academic data visualisations

The gap between unprocessed data and sophisticated knowledge is closed by effective data visualization. Clear and meaningful data presentation in academic research makes difficult findings understandable to readers, improving comprehension, engagement, and impact. This chapter looks at three important kinds of visualisations that are frequently used in scholarly research: thematic presentation for qualitative studies, survey visualisation, and visualisation of experimental results. In addition to highlighting how careful visualisation can enhance clarity and persuasion in academic communication, each section includes examples pertinent to the research context.

## Survey Data Visualisation

In academic research, surveys are a common way to gather data, especially in the social sciences, education, health, and development domains. In order to effectively capture frequency, proportionality, and trends, survey data frequently contains categorical and ordinal variables that call for visual aids.

### Why Visualise Survey Data?

Readers may become overwhelmed by survey results displayed in tables with numerous figures. These numbers are transformed into easily understood graphics by visualizations like bar charts, pie charts, and stacked column charts, which quickly highlight trends and comparisons. They assist researchers in emphasizing important discoveries, supporting claims, and persuading decision-makers or stakeholders. Take, for instance, a study that examined how frequently Accra university students used ICT. Students were asked in the survey if they use digital learning resources frequently, infrequently, never, weekly, or monthly. Here, a bar graph would be an excellent option. While the horizontal axis displays the categories of use, the vertical axis displays the percentage of students. Spending of precious time, for instance.

Frequency	Percentage of Students
Daily	55%

Weekly	25%
Monthly	10%
Rarely	7%
Never	3%

The bar graph visually highlights that more than half of the students use ICT every day, underlining the importance of digital resources in tertiary education. This visualisation quickly informs university administrators and educators of the prevalence of ICT involvement and informs decisions on allocation of resources and curriculum integration.

### **Tips for Effective Survey Data Visualisation**

1. Choose appropriate charts: Use pie charts for simple part-to-whole comparisons, but avoid them for complex data. Bar charts excel at comparing categories.
2. Label clearly: Axes, legends, and data points must be easy to read and interpret.
3. Use culturally relevant colours: For example, colours reflecting national palette (red, yellow, green, black) can enhance connection with local audiences without sacrificing clarity.
4. Avoid clutter: Simplify graphics by focusing on essential categories or grouping less frequent responses under ‘Others.’

### **Visualisation of Experimental Results**

Academic research experimental studies test hypotheses under controlled conditions and often produce quantitative data such as measurements, scores or rates. Visualisation of experimental results effectively involves highlighting the differences between groups, trends over time, or the relationships between variables.

### **Why Visualise Experimental Data?**

Tables filled with values for mean, standard deviation, and p-values may obscure the practical relevance of the results. Graphical representations such as line graphs, scatter plots or box plots facilitate readers' understanding of patterns, variability assessment and assessment of the magnitude of effects. Visualisations also increase transparency and reproducibility in experimental research. Suppose, for example, that a researcher conducts an experiment comparing traditional teaching methods with a new interactive approach to teaching math. Students' test scores were recorded before and after the intervention. The box plot allows an effective visualisation of the distribution of scores for both groups before and after the intervention. The box plot shows the medians, quartiles, and possible outliers to help the reader see whether the new method improves

performance and whether the results are consistent. This visualisation clearly demonstrates to educators and policymakers the potential benefits of adopting innovative teaching methods to improve academic performance.

### **Tips for Visualising Experimental Results**

1. Select the right graph type: Use box plots to show data spread, line graphs for trends over time, and scatter plots for correlations.
2. Indicate statistical significance: Add annotations or confidence intervals to clarify which differences are meaningful.
3. Highlight group comparisons: Use colour or pattern differences to distinguish experimental groups clearly.
4. Include sample sizes: Help readers assess the robustness of results by reporting the number of participants per group.

### **Thematic Presentation for Qualitative Studies**

Qualitative research is the study of understanding human experience, perception and social phenomena, often involving interviews, focus groups or observation. Thematic analysis is a common qualitative method for identifying patterns or themes in text.

#### **Why Visualise Themes?**

Qualitative data visualisations summarise complex narratives into clear and memorable visual formats, which help readers to follow the research story and understand the key findings. While words remain the primary tool, visual aids such as thematic maps, word clouds and flow diagrams support and enrich the narrative. Consider, for example, a qualitative study examining how smallholder farmers deal with unpredictable rainfall and drought. Thematic analysis revealed the main coping strategies: diversification of crops, networks of support within the community, traditional knowledge and migration. The theme map visually organises these themes, showing similarities and discontinuities. For example, community support networks can be extended to shared work and informal credit systems, while traditional knowledge can include seasonal planting calendars and soil protection practices. This visualisation helps policy makers, extension workers and NGOs to quickly understand the lives of farmers and to promote culturally sensitive interventions that build on existing strengths.

### **Tips for Visualising Qualitative Themes**

1. Use hierarchical maps: Display main themes and subthemes to show structure.
2. Incorporate quotes or icons: Small excerpts or relevant symbols can bring themes to life.

3. Keep it simple: Avoid overloading visuals with too many themes or connections.
4. Align visuals with narrative: Ensure the graphic complements and enhances the written explanation.

# Chapter 7: Common errors and how to avoid them

Data visualisation is a powerful tool for communicating research findings clearly and efficiently. However, inexperienced researchers often fall victim to pitfalls that undermine the impact and clarity of their images. In this chapter, we examine three of the most common errors in academic data visualisation: misleading graphs, over-complex design, and inconsistent formatting, and give practical advice on how to prevent them in the future. Using real-life examples from the research context, this chapter will help you create honest, clear and professional data visualisations that will enrich your academic work.

## 1. Misleading Graphs

The primary purpose of a graph is to represent data truthfully and to allow the reader to understand key trends and relationships at a glance. Unfortunately, misleading graphs can distort the interpretation of data and damage the credibility of a researcher. Consider, for example, a study of literacy rates over the past decade. The bar graph is used to compare the percentages of illiteracy. However, the Y axis starts at 50% instead of zero, which makes the differences between the regions appear to be much more pronounced than they are.

### Why Misleading Graphs Occur

Misleading graphs often arise from:

1. Manipulated axes (e.g., truncated or inconsistent scales)
2. Selective data omission or cherry-picking
3. Improper graph types that exaggerate differences
4. Use of 3D or decorative effects that obscure data proportions

## **How to Avoid Misleading Graphs**

1. Always start your axes at zero unless there is a strong, justifiable reason not to (and if you don't, clearly indicate it).
2. Include the entire relevant dataset rather than selectively displaying data points.
3. Choose graph types carefully to suit the data. Avoid 3D charts or pie charts that make precise comparisons difficult.
4. Label axes and data points clearly, so readers can verify the data easily.

## **2. Overcomplicating Visuals**

Data visualisation should facilitate understanding, not confuse it. It is a common error to overload too much information or too many variables in a single graphic and thus overwhelm the reader rather than enlighten them. Consider, for example, a survey that analysed the factors that influence youth unemployment in Togo, including education, family background, urbanisation, and access to technology. A researcher creates a single scatter plot with 10 different colored dots for each region, multiple regression lines, and a legend with 15 categories. Readers struggle to understand which factors are relevant or what the overall trend is.

### **Why Overcomplication Happens**

Researchers may want to present all their findings at once, or they may not know which data points are the most relevant. This may lead to:

1. Crowded charts with many lines, bars, or colours
2. Complex multi-layered visuals without a clear focus
3. Overuse of legends, labels, and annotations

### **How to Avoid Overcomplicating Visuals**

1. Focus on one key message per graph by avoiding cramming multiple stories into a single figure.
2. Use multiple simple visuals rather than one complex chart when presenting multidimensional data.
3. Limit the number of categories or variables shown at once, and use consistent, meaningful colours.
4. Utilise white space and clear labels to guide readers' eyes through your story.



### **3. Inconsistent Formatting**

Consistency is often overlooked, but it is essential to professionalism and to the understanding of the reader. Inconsistent font styles, colours, sizes, or labelling styles may distract readers and obscure the story your data is intended to convey. For example, a graduate thesis on agricultural productivity contains four graphs drawn up in a few weeks. One graph uses a sans serif font and the other uses a serif font. The colours vary from chart to chart; green is used for maize in one chart, but red for cassava in another. The axes are sometimes bold, sometimes in italics, and the legends appear in different positions. The inconsistencies make the dissertation appear fragmented and unprofessional.

#### **Why Inconsistent Formatting Occurs**

1. Lack of a style guide or template
2. Copy-pasting visuals from different sources without harmonising them
3. Rushed work or unfamiliarity with visualisation tools

#### **How to Avoid Inconsistent Formatting**

1. Develop or adopt a consistent style guide before creating visuals (font type, size, colours, labelling conventions).
2. Use templates or master layouts where possible.
3. Review all charts for uniformity in font, colour schemes, axis labelling, and legend placement.
4. Be mindful of colourblind-friendly palettes, especially when sharing research broadly.

### **Conclusion**

Avoiding these common mistakes is crucial to producing clear, honest, and professional data visualisations in academic research. For researchers, learning these principles will not only improve your immediate work but also build a reputation for integrity and clarity in academic communication. Your goal is to create a visual that speaks truthfully, simplifies complexity, and presents your data with respect. Effective data visualisation can facilitate greater comprehension, dialogue, and impact by serving as a strong link between your research and your readers.

## Chapter 8: The future of data visualisation in research

Data visualisation remains a potent link between complex data and lucid comprehension in the rapidly evolving field of academic research. However, as technology develops, the future of data visualisation will not involve producing static charts and graphs; rather, it will involve redefining how knowledge is shared and comprehended through the use of intelligent tools and interactive narrative techniques. This chapter examines two key developments that will influence research data visualisation in the future: interactive dashboards that use data to tell a story and visual tools. We also draw attention to the usefulness for researchers.

### AI and Machine Learning Visual Tools

Machine learning (ML) and artificial intelligence (AI) are not futuristic ideas anymore; they are already incorporated into data visualisation and research. Artificial intelligence has made it possible for tools to analyse massive datasets, find hidden patterns, and produce visualisations that dynamically adjust to new data, giving researchers faster and more precise access to deeper insights.

### What AI and ML Bring to Data Visualisation

Researchers frequently use manual procedures to choose variables, make charts, and decipher formulas in traditional data visualisation. However, deep learning and machine learning have already automated a large number of these tasks. An artificial intelligence tool might, for instance, highlight correlations, recommend the best visual format for a particular type of data, or even spot irregularities that the human eye might overlook. Artificial intelligence visualisation tools can transform raw data into actionable images that policymakers can trust, where public health research is crucial for monitoring the incidence of malaria or assessing maternal health programmes. Consider an AI dashboard that automatically creates disease-specific heat maps, forecasts future trends, and continuously examines medical clinic records across the Ashanti region. Local health officials could more effectively distribute resources and stop the spread

of illness with the help of this real-time visualisation. Researchers have produced dynamic clustering maps that illustrate the relationship between literacy and access to electricity and the Internet by incorporating machine learning algorithms into their data visualisation pipeline. Education stakeholders have benefited from these AI-powered visualisations by better understanding intricate socioeconomic relationships and creating focused interventions. Similarly, to visualise crop health from satellite photos, agricultural scientists are using AI-based image recognition tools more and more. In areas most impacted by climate change, these visualisations help to ensure food security by enabling farmers and extension agents to forecast yields and keep an eye on farm conditions. The capacity of AI and ML to convert static, occasionally debilitating data into perceptive, interactive visualisations that bolster evidence-based decision making is their greatest strength in data visualisation. The use of these technologies by researchers will result in more accurate information, quicker data processing, and a bigger social impact. Institutions hoping to lead innovative research should prioritise integrating artificial intelligence into data visualisation as funding and infrastructure improve.

## **Interactive Dashboards and Storytelling with Data**

Gone are the days when research findings were buried in thick reports and tables. Today, interactive dashboards and narratives that engage audiences by making data tangible are the future. Interactive visualisation tools enable users to explore data sets through filters, drill-down, and real-time updates, creating a personalised experience that drives understanding and action.

### **The Rise of Interactive Dashboards**

Several visual components are combined into a single interface in interactive dashboards, which changes when users choose different variables or periods. Policymakers, educators, and community leaders who must consider data from several perspectives before making decisions will find this method especially helpful. Interactive dashboards can democratize access to research findings, where there are significant differences in data literacy. For instance, district officials could spot trends and issues without requiring sophisticated statistical training if the Department of Education implemented a dashboard that shows attendance, performance, and enrollment by district.

### **Storytelling Through Data**

The art of creating a narrative around data visuals to emphasise important points and elicit strong feelings is known as data storytelling. Raw data can be transformed into memorable insights that impact public opinion and policy with the aid of narrative storytelling. Consider a researcher looking into the effects of sanitation initiatives. Rather than merely displaying survey data tables, the researcher crafts an interactive story that begins with maps that depict the regions before and after the

project, followed by health outcome graphs and, lastly, testimonies that are connected to the data. Both practitioners and policymakers will find the findings compelling and easy to understand thanks to this narrative approach.

### **Practical Tools and Platforms**

Interactive dashboards and storytelling are made possible by a number of tools, such as Tableau, Power BI, and open-source alternatives like Google Data Studio. These tools are becoming more and more mobile-friendly, which will help reach audiences throughout, where smartphones are frequently the main way to access the Internet. These platforms allow researchers to design dashboards that are tailored to particular audiences. For instance, the Public Health Dashboard might provide epidemiologists with in-depth analysis and community health workers with simplified visualisation. More than just a trendy format, interactive dashboards and storytelling are crucial for directing well-informed action in developmental sectors. By making data visually and interactively accessible, researchers can encourage accountability, transparency, and participatory management. When the data stories connect with the communities' lived experiences, they become stakeholders in their development.

### **Conclusion**

Data visualisation in research has a bright future ahead of it. By automating analysis and producing adaptive images, artificial intelligence and machine learning tools hold the potential to open up new levels of comprehension. Research communication is improved by interactive dashboards and narrative, which make data interesting, approachable, and useful for a variety of audiences. Adopting these innovations is a strategic necessity for researchers, not just a way to stay current. Researchers can enhance the influence of their findings in government, agriculture, education, and health by incorporating interactive storytelling and artificial intelligence-based visualisations into their work. More significantly, they can help close the gap between information and judgment, promoting sustainable development across the board. Only you, as a novice researcher or data enthusiast in Ghana, have the power to influence the future. Investigate artificial intelligence tools, try out interactive dashboards, and use your data to create compelling narratives. Gaining proficiency in data visualisation is an exciting journey, and you might make another breakthrough.

## Chapter 9: Simple tips to pick the right chart

Data visualisation in academic research is not just about making your findings look better; it's also about effectively communicating your findings. While a poorly designed diagram can cause confusion and misinterpretation, a well-designed diagram can help your audience understand your message right away. Knowing which graph to use to illustrate the appropriate situation is crucial for presenting data that is both convincing and instructive, especially for novice researchers and throughout Africa. With relatable examples from the research setting, this chapter provides ten easy-to-implement suggestions to assist you in selecting the best graph for your data. These guidelines will act as a quick reference for effective data visualisation, regardless of whether you are working on a dissertation, thesis, policy paper, or journal article.

### 1. Start with the Question You Want to Answer

You should take a step back and consider the primary question your data is intended to answer before choosing the type of chart or graph to use for your data presentation. This crucial step guarantees that your data visualisation stays on topic and aligned with your study objectives. Ask yourself if you want to compare figures, show changes over time, or show proportions in a summary. For example, do you want to compare enrollment figures between different regions, identify trends in malaria cases over the last decade, or show the percentage of households that have access to clean water? By clarifying the specific issue your data should address, you provide a solid basis for choosing the most appropriate and meaningful visual representation. Consider a scenario in which your research question is: Which region has the highest enrolment rate for free secondary education in 2024? In this case, you focus on comparing enrolment rates between regions. This immediately narrows down your visualisation options to those that are most suitable for comparison-based visualisation when needed for geographical focus. The clarity of the research question directly informs the decision to visualise and helps to avoid misleading or cluttered presentations. For researchers and data analysts, a straightforward yet important piece of advice is to always state your research question clearly and let it dictate the kind of chart you make. This will guarantee that the visual representation accurately reflects the meaning of the data.

## **2. Use Bar Charts for Comparisons**

When comparing various groups or categories within a dataset, bar charts are among the most effective and intuitive visualisation tools available. Both technical and non-technical users can benefit from them because of their simplicity, clarity, and ease of interpretation. Rectangular bars that are proportionate in length or width to the size of the category are commonly used in bar charts to show the value of each category. Without requiring complex statistical analysis, viewers can rapidly comprehend patterns, differences, and trends between groups thanks to this visual representation. Additionally, you can add colours, labels, and legends to the bar charts to make them easier to read and draw attention to particular data points. A vertical bar graph, for instance, can be used to effectively display the data for a researcher studying maternal health clinics in a district. Each bar in this graph would stand for a distinct area, and the height of each bar would indicate the total number of clinics in that area. A presentation like this quickly identifies which areas have greater resources and which might need more funding for healthcare. Comparing is made easier by this visual format, which makes it obvious that there are differences. Additionally, a horizontal bar graph is advised when working with categories that have lengthy names or where there is more horizontal space. By doing this, category labels are kept readable and clear, maintaining their usefulness without overpowering the presentation.

## **3. Line Charts Are Best for Trends Over Time**

Line charts are among the most effective visualisation tools if your data shows changes over time, measured in days, months, years, or decades. To make it simple for viewers to see how one or more variables are changing over time, they are made to display continuous data points joined by straight lines. Finding trends, cycles, and irregularities in data collections is made easier with the help of this kind of chart. It enables analysts and researchers to promptly identify seasonal patterns, abrupt swings that might require further investigation, and upward or downward movements. In disciplines like economics, public health, education, and environmental studies, where observing how data behaves over time is essential for forecasting and decision-making, line charts are frequently used. For instance, the timeline would be extremely helpful to a health researcher tracking COVID-19 cases between March 2020 and December 2021. The number of cases reported in a given month is represented by each point on the line chart in this scenario, and the lines that connect the points clearly show how the infection rate has evolved. Key events like the initial surge in cases, the peaks during epidemic waves, and the subsequent declines following interventions like lockdown and vaccination would all be readily visible on such a graph. Using distinct colours, markers, or line styles is crucial when plotting multiple variables, such as when comparing the incidence rates of various age groups or geographical areas. This procedure improves clarity and guarantees that readers can understand the trends presented without any confusion.

#### 4. Use Pie Charts for Simple Proportions Only

Pie charts are very powerful visual tools to show how different components contribute to the overall picture, which makes them ideal for datasets with a limited number of categories. They are best suited for situations where the aim is to highlight the relative proportions of the different categories in a visually appealing and immediately comprehensible way. For example, if a research study examines household drinking water resources in a rural community in the Volta region and finds that 60 per cent of households use boreholes, 25 per cent rely on river water, and 15 per cent buy bottled water, the distribution would be clearly and neatly illustrated. The audience will quickly see that boreholes are the main source of drinking water, while potable water is the smallest share, without having to read complicated numerical tables or lengthy explanations. However, it is important to exercise discretion in determining how many categories to include in the overview of the torrent. Visual clarity decreases significantly when more than five categories are included, as the graph becomes cluttered and the differences between the slices become harder to see. In such cases, the bar chart often serves as a better alternative, offering a more orderly and legible comparison of the different categories. For example, if the same water resource study included other categories such as rainwater, bottled water and municipal water, the bar graph would better accommodate these six data points by showing them side by side, while preserving both clarity and the ability of the viewer to correctly interpret the data. Therefore, although pie charts offer aesthetic and communicative value, their use should be limited to simple, straightforward comparisons.

#### 5. For Complex Parts, Try a Stacked Area or Tree Map

Stacked area and tree maps can offer strong and eye-catching insight when your data contains several components over time or within a structured category. If you wish to display how the makeup of the data categories has changed over time while maintaining the general trend, stacked area charts are particularly helpful. A stacked area map, for instance, might help analyse how different crops, including rice, yams, cassava, and maize, contribute to the overall agricultural output between 2018 and 2023. In this visualisation, each crop is represented by a colored area, stacked one above the other, showing both the individual trends of each crop and how they contribute to the overall harvest. This allows readers to easily track both the specific performance of individual crops and the overall agricultural yield over a selected period. Alternatively, a tree map may be used if the aim is to show the relative distribution of different categories within a single period or structure. In agricultural data, a tree map could effectively show how each crop contributes to total production in a given year by assigning a rectangle to each crop in proportion to its value. The size and colour of each section would represent the crop yield about the others, providing a quick comparative overview at a glance. However, it is important to use these charts thoughtfully and sparingly, ensuring that the data labels are clear and the visualisation is not cluttered. The excessive use of complex charts can overwhelm the audience and obscure the intended message, so choosing the right chart

type for the story the data is intended to tell is critical in academic and professional presentations.

## **6. Scatter Plots Are Great for Patterns and Outliers**

Scatterplots are among the most effective and aesthetically pleasing tools available for examining the relationship between two continuous variables. With one variable plotted on the x-axis and another on the y-axis, the scatter plot displays the data points on a two-dimensional graph. This enables the viewer to observe the relationship between changes in one variable and changes in the other. Finding patterns, clusters, and outliers in a data set that might otherwise go unnoticed in a spreadsheet is made easier with the help of scatter plots. They help to identify possible linear or non-linear relationships and to assess the direction (positive, negative or null) and strength of these relationships. In addition, scatterplots provide a quick visual summary which may support or undermine hypotheses in research. In public health research, for example, a researcher who examines the relationship between the number of nurses in a given district and the corresponding rate of maternal mortality may use a scatter plot. Here, each dot represents a municipality, with the number of nurses on the x-axis and the mortality rate on the y-axis. If the points are inclined to fall from left to right, this may indicate a negative relationship, suggesting that higher numbers of nurses are associated with lower rates of maternal mortality. Conversely, a series of dots without any discernible pattern may indicate no significant relationship between the denominations. To improve interpretation, the addition of a trend line may help to visualise the overall direction and strength of the relationship, and thus help researchers communicate their findings and base policy recommendations on clear and evidence-based patterns.

## **7. Use Bubble Charts When Size Matters**

Bubble charts are an advanced form of scatter plot that allows researchers and data analysts to represent three dimensions of data in a visually appealing graphic. In a bubble diagram, the size of each bubble represents the third variable, whereas in a conventional scatter plot, two variables are plotted along the X and Y axes. This makes it possible to identify trends, relationships, and patterns among several variables at once. Bubble charts offer a more thorough view of complex data sets that would be challenging to interpret using conventional two-dimensional charts, and are especially helpful when examining the interactions between three distinct quantitative variables. For instance, a bubble diagram can quickly offer insightful information in an educational study of high school enrollment, school enrollment, and regional literacy rates. The size of each bubble would indicate the corresponding literacy rate, the x-axis could display enrollment numbers, and the y-axis the number of schools in each region. This visual aid makes it easier to see how literacy outcomes are related to areas where higher enrollment is associated with more or fewer schools. To prevent misunderstandings or visual clutter, it is crucial to make sure that the bubble sizes are appropriate and sufficiently varied. The diagram's readability and analytical value may be further enhanced by meticulous colour selection and clear marking.



## **8. Choose Histograms for Data Distribution**

The distribution of data at continuous intervals or ranges can be visually represented with the help of powerful graphical tools called histograms. Histograms concentrate on numerical data and display how values are distributed across a range of intervals, commonly referred to as tiers, in contrast to bar charts, which usually display categorical data. Because of this, they are especially good at spotting trends, patterns, and the general form of data sets, whether they are symmetrical, skewed, or non-standard. The histogram is a fundamental tool in domains like education, health, business, and social science because it allows researchers to quickly see the frequency of data points in each range and pinpoint concentrations or gaps. For example, a researcher studying the distribution of Basic Education Certificate Examination (BECE) scores among students in the metropolis of 2024 could use a histogram to gain insight into student academic performance. On the X axis, the researcher places score intervals, for example, 200-220, 221-240, 241-260, etc., and on the Y axis, the number of students scoring in each interval. This visual presentation would allow researchers to quickly identify which ranges have the highest or lowest frequencies, detect any unusual high or low scores, and assess the general pattern of student performance. However, it is important to keep the intervals equal in width to maintain consistency and to ensure that the visual representation of the data remains accurate and easy to compare.

## **9. Avoid 3D Charts Because They Confuse More Than They Help**

Although 3D graphs may seem visually striking and impressive, they often pose considerable problems when it comes to the accurate interpretation of data. Values and relationships may be distorted by the additional depth in 3D visualisations, particularly if the elements overlap or if some of the chart's points are positioned awkwardly. Readers may misjudge the size of data segments as a result, which makes it challenging to draw reliable conclusions. Such visual distortions jeopardise the integrity of the data presentation in academic research, where accuracy and clarity are crucial, and they may potentially mislead viewers who depend on visuals to form an opinion quickly. Consider displaying the distribution of school feeding programs among the five regions using a 3D pie chart. Smaller pieces might seem compressed or obscured by larger ones in this situation, making them nearly invisible or less significant than they are. Readers may undervalue the representation of particular regions as a result of this visual bias, which could mislead them about the extent of policy or resource allocation. Pure and basic 2D rudiments are advised in order to steer clear of these pitfalls. In addition to maintaining data integrity, they provide readers with an easier-to-use and more accurate means of accessing and interpreting information.

## **10. Keep It Clean and Readable. Less Is More**

Simplicity is not just a design choice in data visualisation. It is a basic principle to strengthen confidentiality. When you visualise data, each element in the chart or graph should serve a clear purpose. Blurred images with excessive colour, heavy grid lines, or ornamental embellishments often distract the viewer and obscure the main message.

Instead, a focus on clean, simple design helps the audience quickly grasp the message of the story of the theorem. For example, the use of only two or three complementary colours may highlight important trends or comparisons without dazzling the eye. Clear axis labels and readable fonts contribute significantly to the accuracy of the report by helping the viewer to distinguish between different denominations. By removing unnecessary elements, the visualisation is more impactful and accessible, particularly for a wide variety of audiences that may not have technical knowledge. To illustrate this, consider a graph showing the growth of mobile money transactions between 2010 and 2024. A well-designed graph would contain identified axes showing time on the x-axis and transaction volume on the y-axis, with perhaps two different colours representing different types of transactions or years with a significant change. Background images or textures should be avoided as they do not serve any analytical purpose and may detract from the transparency of the diagram. Always question the value of each element: does it help the story transcend? If the answer is no, the best thing to do is to suspend the bloodshed. Discontinued. Such a minimalist approach not only makes the data more palatable but also respects the viewer's time and attention, making visualisation a powerful communication tool.

## **Conclusion**

With practice and commitment, even a novice researcher can become an expert at effectively visualising data. You can select the best graphs for your study and make sure that your data is understandable and convincing to your audience by adhering to these straightforward yet effective guidelines. These guidelines will help you confidently visualise your findings, whether you are working on a project about gender inequality in Togo's higher education, the prevalence of malaria in Uganda, or youth unemployment in Nigeria. Another crucial ability for any academic researcher is the ability to integrate various charts into dashboards and reports for multivariate data reporting, which we will examine in the upcoming chapter.

## Chapter 10: Concluding remarks and take home

Visualisation of data is more than just a method. It is the fundamental language of scholarly inquiry, converting uninterpreted data into insightful understandings. Gaining proficiency in this language is a significant step toward credibility, impact, and clarity for those new to the academic world. As this book comes to a close, it is crucial to consider the process of comprehending, producing, and interpreting visual data for research, especially within the vibrant and diverse Ghanaian academic community.

### **The Power of Visualisation in Academic Research**

Visualising data is essential in a world where important decisions about governance, agriculture, health, and education are frequently influenced by academic research. Consider a study that looked at how central region enrollment rates were affected by free high school policies. Readers may become overwhelmed if enrollment statistics are presented solely as a string of numbers. However, a well-designed bar graph or line graph turns abstract data into an engaging story by graphically illustrating trends, spikes, and trends over time. In addition to influencing stakeholders and policymakers to make well-informed decisions that could impact the educational future, this clarity also engages the general public. Visualisation acts as a link between intricate statistical results and real-world comprehension. A public health researcher examining the prevalence of malaria, for instance, can efficiently identify hotspots using heat maps. This visual cue has a greater impact than a textual description alone because it highlights areas that need immediate attention.

### **Enhancing Communication and Impact**

Effective data visualisation involves more than just aesthetics, as you have discovered throughout this book. Confidentiality comes into play. For your research to be truthful and credible, you must select the appropriate kind of graph, chart, or map, follow ethical standards, and guarantee accuracy. Globally, where audiences might include government representatives, local community leaders, and academic peers, it is crucial

to customise your data visualisations to be understandable and culturally appropriate. Using well-known symbols or culturally significant colours, like the red, gold, and green of national flags or symbols, for instance, can enhance the visual experience and make the research easier to understand and more memorable.

### **Ethical Presentation and Integrity**

The ethical obligation that researchers have when they visualise data is a key lesson that this book reinforces. Selective presentation, skewed weights, or misleading graphs can harm your reputation and credibility within the communities you research. For instance, manipulating the y-axis to exaggerate youth unemployment may sensationalise the issue, but it will ultimately erode trust in your study and hinder practical solutions. A dedication to honesty and openness in data visualisation as a novice researcher will guarantee the accuracy of your work and respect the stakeholders and participants in your study.

### **Practical Steps Forward for Researchers**

The skills and principles shared in this book are your starting toolkit. Here are some practical steps to continue your growth in data visualisation:

1. **Practice Regularly:** Use software tools like Microsoft Excel, Tableau, or open-source options like R and Python to experiment with different visualisation types. Start with data from sources like the Ghana Statistical Service or local university research to make your practice relevant and grounded.
2. **Seek Feedback:** Share your visuals with peers, supervisors, or community members. Ask if your graphs and charts convey the intended message and are culturally appropriate.
3. **Stay Updated:** Data visualisation is an evolving field. Follow academic journals, attend workshops, or join online communities focused on visualisation techniques to keep your skills sharp.
4. **Reflect on Audience:** Always consider who will view your visuals. Academic researchers, policymakers, students, and local communities all have different needs. Tailor your visuals accordingly.

### **Final Thoughts**

To sum up, data visualisation is a vital tool that enables researchers to convey their findings with impact, clarity, and precision by turning unstructured data into captivating stories that appeal to a wide range of audiences. Gaining proficiency in the art of effective visualisation is essential for beginning researchers because it not only makes their work more approachable and credible but also establishes them as perceptive storytellers with the ability to inform, uplift, and effect significant change in

their communities and fields. You can take your research beyond numbers and statistics by embracing data visualisation with assurance and ethics. This gives it vitality and relevance that can impact practice, policy, and future research. Using the power of visual tools will be crucial in influencing the future of scholarship and innovation in Ghanaian academic research, where effective communication is still a major challenge. This will allow researchers to break down barriers and establish connections with a larger audience both domestically and internationally.

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