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THE MINISTRY OF SCIENCE AND EDUCATION OF THE REPUBLIC OF AZERBAIJAN

AZERBAIJAN STATE UNIVERSITY OF ECONOMICS

UNEC BUSINESS SCHOOL

MASTER DISSERTATION

ON THE TOPIC

"DATA VISUALIZATION TECHNOLOGY THROUGH BUSINESS INTELLIGENCE SERVICE"

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DATA VISUALIZATION TECHNOLOGY THROUGH BUSINESS INTELLIGENCE SERVICE

ABSTRACT

The benefits of employing business intelligence (BI) and data visualization tools are researched by many companies and researchers, but despite many firms employing this technology, there are still a lot of businesses which are not familiar with it. Those companies are mostly located in developing world and it is hard for them to make a switch as it requires a lot of effort and some cultural change. Nevertheless, the transition is inevitable as competition level is increasing and firms are coming up with the new ways of competing every year. This research is conducted with the purpose of speeding up the process by providing useful information on how the transition changes the way businesses are operating and benefits they get from that. The paper starts with the analysis of the historical background of both BI and data visualization technology and their role in improving the efficiency of businesses. Examples of some data visualization tools and methods are provided in the paper and some suggestions on how to utilize them are given. The paper also describes the importance and benefits of BI and data visualization technology in the modern world as well as their applications and challenges. It concludes by the evaluation of the role of data visualisation tools in success of two large global companies – Netflix and Procter & Gamble as well as analysis of the value of data visualization tools to one of the Azerbaijani private schools – LANDAU School. The data used in the research is based on both primary and secondary research analysis methods which includes analysis of online survey conducted among the teachers of LANDAU School, statistical data and comparing and contrasting different expert views.

Key words: Business Intelligence, Data Visualization, Technology, Competition, Decision-Making

ABBREVIATIONS

BI	Business Intelligence
DSS	Decision Support Systems
EIS	Executive Information Systems
ETL	Extract, Transform, Load
OLAP	Online Analytical Processing
ERP	Enterprise Resource Planning
ROI	Return on Investment
NPV	Net Present Value
IRR	Internal Rate of Return
TCO	Total Cost of Borrowing
KPI	Key Performance Indicator
P&G	Procter & Gamble

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INTRODUCTION

Relevance of the dissertation work: In the realities of the modern world, it is very hard to launch and operate a business as the market is very competitive. To survive the competition, companies must come up with an idea of how to distinguish their product from the products of their rivals. This can be done by, for example, improving the existing product, creating an innovative product or by reducing the cost of production which will allow a business to reduce the price and gain large market share. Correct utilization of BI and data visualization tools is the modern solution for businesses on how to achieve those objectives of distinguishing the product and gaining a large market share. Governments and private sector firms of many countries are investing a lot of money and aiming at achieving technological advancement. Governments make sure that their macroeconomic objectives are met while firms try to gain a competitive advantage and maximize their profits. The technology that worth investment and will help firms and governments to achieve their objectives is business intelligence and data visualization. Data visualization technology has become an important tool for businesses to draw insights from massive volumes of data. Companies may better comprehend their processes, spot trends and patterns, and make choices based on data that increase their bottom line by employing data visualization. Organizations can access the resources and services they seek to analyze, evaluate, and interpret their data through an effective platform, the Business Intelligence Service (BI). Businesses can better understand their operations with the help of BI and make well-informed decisions that will lead to growth. Investment in business intelligence and data visualization software allows businesses to make decisions based on data as well as find operational inefficiencies and areas where their procedures can be improved and waste reduced. It helps them to enhance their supply chain management, increase sales, gain competitive advantage and customer satisfaction, capture bigger market share and increase revenue.

The purpose of the dissertation: The purpose of this research is to evaluate how the development of BI and data visualization tools has affected the patterns of

business performance over the last years. The paper introduces modern BI and data visualization tools to businesses, explains the significance of employing those tools in today's competitive market and gives the companies advice on how to correctly utilize this technology. The paper attempts to mostly help the firms in developing countries that are not familiar with BI and data visualization technology to understand the value of employing that technology. With this purpose, the research analyzes two large global companies' data and describes the role of BI and data visualization tools in their success. Alternatively, this paper describes the current level of employment of data visualization tools at one of the Azerbaijani private schools – LANDAU School and offers the suggestions on how to further improve the performance of that school through investment in employee trainings and utilization of additional data visualization technology. Based on the example of LANDAU School, the research paper concludes with suggestions to all the other companies on how to utilize data visualization technology to its maximum extent.

Business research methods used in the dissertation work: This dissertation is based on both primary and secondary research analysis methods which includes analysis of online survey data conducted among the teachers of LANDAU School, statistical data and comparing and contrasting different expert views. In addition to that, the cases of two large companies are analyzed and relevant outcomes are discussed.

Dissertation database: As a database, this dissertation utilized the personal yearly reports of Netflix and Procter & Gamble, scientific research conducted by various international researchers as well as global research companies, their statistical reports and the data collected through the online survey conducted among the teachers of LANDAU School.

Limitations of dissertation work: The major limitation of this work is a lack of access to companies' internal databases as this carries out a confidential character. The data on particular problems that were solved at Netflix and Procter & Gamble using BI and data visualization technology as well as information on other activities carried out by the company with the purpose of increasing the sales could have been

very helpful for the purposes of this research work. Similarly, as LANDAU School is not a public limited company, its financial reports are not publicly shared and it is difficult to identify what decisions the management of the school has made to increase the number of students willing to study there. Finally, the difficulty of measuring the value of BI and data visualization tools for organizations is also a limitation because this may not be the only factor contributing to the success of the companies. Lack of the access to the confidential data restricts the ability to carry out a proper regression analysis and get accurate results.

Practical results of the dissertation work: This dissertation work identified the benefits of employing BI and data visualization technology for companies, especially the ones located in developing countries where BI and data visualization tools are not popular, analyzed various data visualization tools together with their benefits and drawbacks as well as provided suggestions on how to improve business performance using data visualization technology. All this information should help companies to achieve their objectives and make a decision on whether to invest in BI and data visualization software or not.

Organization, enterprise and business areas where the results can be used: The results of this research can be used in almost all business areas because technological progress has reached nearly all industries. Nevertheless, the main business fields that will get the most benefit from this work include finance, marketing, healthcare, education, renewable energy, and etc. These industries are already benefitting from BI and data visualization technology in developed world. Hopefully, in the near future, developing countries will also utilize this technology.

The paper consists of introduction, three chapters, conclusion, 2 tables and 25 figures. While working on the dissertation, 56 sources were utilized.

CHAPTER I. THE CONCEPTUAL FOUNDATION OF BUSINESS INTELLIGENCE AND DATA VISUALIZATION

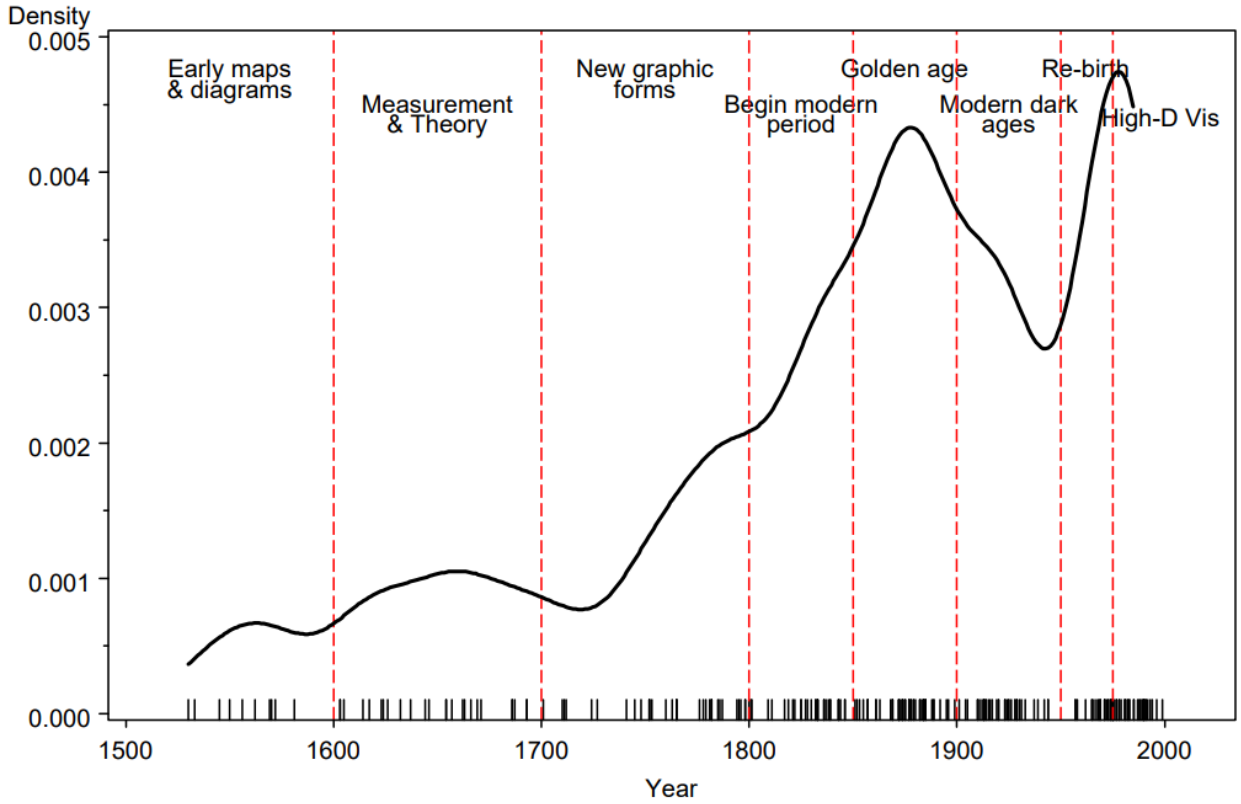
1.1. The History of Data Visualization and Business Intelligence System Development

The first part of the thesis is dedicated to researching the history of data visualization, how first visualization elements were established and affected the development of science. In addition, the process of establishment and growth of business intelligence is also examined and analyzed. Business intelligence tools and data visualization techniques are technological advancements used by many public and private companies today to achieve their objectives. Business Intelligence (BI) is "a set of methods, processes, architectures, applications, and technologies that gather and transform raw data into meaningful and useful information used to enable more effective strategic, tactical, and operational insights and decision-making to drive business performance" (Evelson & Nicolson, 2008). Data visualization, on the other hand, is a part of business intelligence which presents the data in graphical or tabular form making data interpretation and decision-making process easy. Visualization, in general, is the process of creating a perceivable image in one's mind by using a mix of visual elements and colors or positions (Zheng, 2018).

It is helpful to begin with historical background in order to comprehend both present and potential developments in the subject of data visualization. Although the roots of data visualization date back to the second century AD, most advancements have taken place over the past 250 years, mostly in the last 30 years. The depiction of quantitative information on graphs started from earliest creation of maps and then developed into statistical graphics that are used in various fields including medicine and science. The very first table that has been recorded was constructed in Egypt in the second century to arrange astronomical data as a navigational tool. According to the research published in 2006 and conducted by Michael Friendly, professor of psychology at York University, the history of data visualization can be divided into, what he calls, "milestones" (Friendly, 2006). Each milestone has its own title and

unique characteristics. The milestones are depicted in Figure 1 and are briefly

Figure 1. "Milestones: Time Course of Developments"



Source: Michael Friendly, "A Brief History of Data Visualization", https://www.researchgate.net/publication/226400313_A_Brief_History_of_Data_Visualization, 2006

analyzed in the following parahraphs.

The first milestone called "Early maps and diagrams" covers pre-17th century period. Friendly suggests that this period is characterized by the creation of the earliest geometric diagrams showing the positions of stars and other celestial bodies as well as creation of maps that helped in navigation and exploration. The beginning of data visualization was made in this period (Friendly, 2006: p. 3). The second milestone was characterized by the birth of probability theory, the rise of analytic geometry and coordinate systems, the beginnings of demographic statistics, theories of measurement and estimation as well as "political arithmetic" which studies population, land, taxes, value of goods, etc. to understand the wealth of the state. As some basics of statistical theory and usage of graphs to depict the data were already established, these elements expanded into new fields and visual forms throughout the 18th century, which corresponds to the third milestone called "New Graphic

Forms". For example, mapmakers started attempting to illustrate more on a map than merely location which led to the development of isolines and contours and the establishment of thematic mapping of physical quantities.

The next milestone utilized the innovations of the previous periods and experienced statistical graphics and thematic mapping growth at an exponential rate that cannot be compared with the old times. Some of the developments of this time period included invention of bar and pie charts, histograms, line charts, line graphs and time-series plots as well as comprehensive atlases and graphical analysis of lines of magnetism and weather. All these innovations covered the period from 1800 till 1850. In acknowledgment of the expanding significance of numerical data for social planning, industrialisation, commerce, and transportation, official state statistical offices were established across Europe in the second half of the 19th century, which corresponds to the 5th milestone. Large data sets could be analyzed using statistical theory. These innovations were so diverse that it would be impossible to list them all, but a few themes stand out. Several important innovations allowed graphics to go beyond a simple sheet of paper. 3D surface maps of population data, the use of divided circle diagrams on map, polar area charts, semi-logarithmic graphs, age pyramids and etc. were developed. A special note should also be made of the several additional national statistical atlases and albums produced by the U.S. Census Bureau.

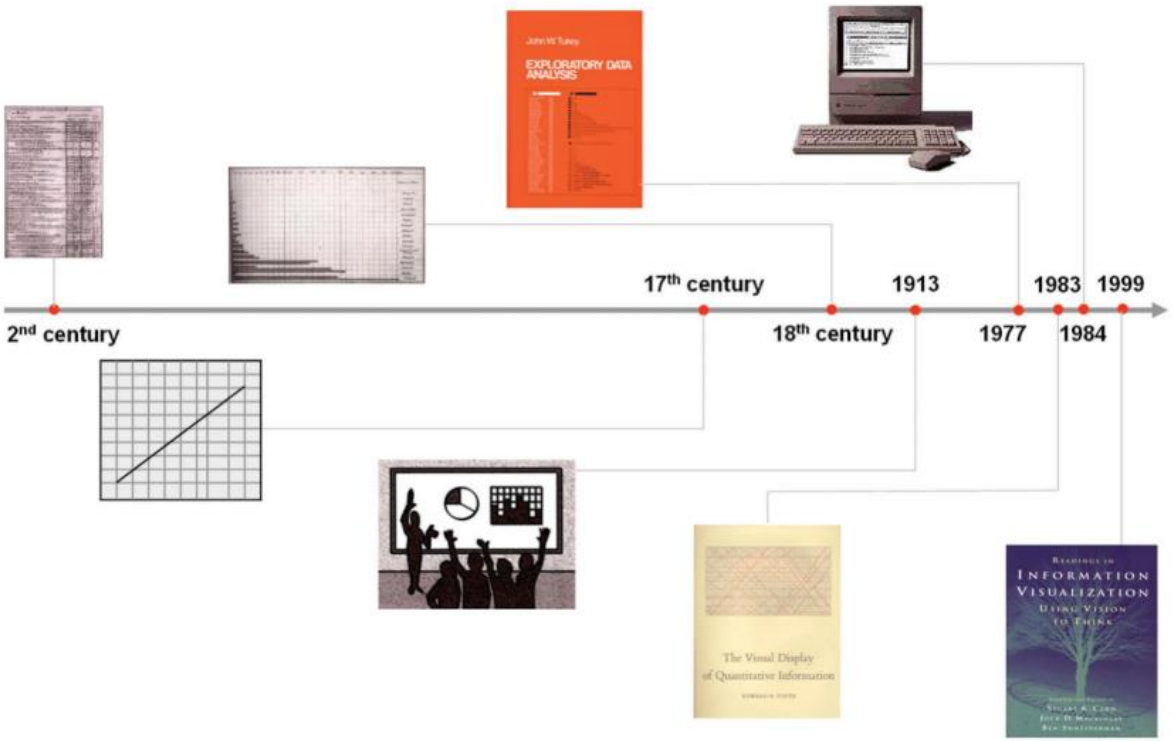
The late 1800s' excitement for visualization had been largely replaced by quantification and formal, frequently statistical, models because compared to pictures and images, the data was more accurate, as were the parameter estimations and, in particular, the ones with standard errors. In the middle of the 1960s, data visualization started to emerge from hibernation while still being influenced by the formal and numerical ethos that had been prevalent from the mid-1930s. Data analysis was recognized as a branch of statistics separate from mathematical statistics. Exploratory Data Analysis was invented and by the end of this re-birth period, significant cooperation was formed. New paradigms, languages, and software tools for expressing statistical concepts and creating data visuals were made

available as a result that would then trigger a rapid expansion of fresh visualization strategies.

During the last milestone which covers the period from 1975 till today, data visualization has evolved into a well-developed, active, and multi-disciplinary study field over the past quarter of the 20th century, and desktop computers are now equipped with software tools for a variety of visualization techniques and data formats. The visualization techniques that are used by companies nowadays were all developed in this period. In recent years, visualization of data has evolved into a well-established field of research in universities. Numerous universities now have faculty members who specialize in visualization, and some of them offer outstanding courses that cater to the requirements of a large number of graduate students who generate valuable research studies and prototype applications. This academic society is comprised of members not only from computer science, but also from many other fields, like psychology and business, providing a framework for an extensive amount of innovation while relying on the established practices of more advanced fields.
Another view to the history of data visualization is suggested by Stephen Few, Principal of the Consultancy at Perceptual Edge. He also describes the whole history by dividing it into timelines which can be observed in Figure 2. As we can notice from this figure as well, most of the innovations in the field of data visualization started from 17th century. The image that Few (2007) offers is more colorful and detailed in terms of years and illustrations depicted, but overall it provides the same information as the Friendly (2006) in his own research paper.

The history of BI differs from the history of data visualization and although data visualization is a part of BI, its history is older than BI's history. The fundamental reason for this is that BI requires technology that came to existence relatively recently. Since the late 19th century, BI has had a distinguished and long history. The research of Frederick Winslow Taylor, who is regarded as the founder of scientific management, contains one of the earliest descriptions of BI. Taylor employed time and motion studies to examine factory work in the late 19th and early 20th century to find inconsistencies. His strategy, which required gathering and

Figure 2. "History of Data Visualization Timeline"



Source: Stephen Few, "Data Vısualızatıon Past, Present, And Future", https://mail.perceptualedge.com/articles/Whitepapers/Data_Visualization.pdf, 2007

evaluating data to increase efficiency, served as a basis for contemporary business intelligence. In 1865, Richard Millar Devens used the term business intelligence in his "Cyclopædia of Commercial and Business Anecdotes" to explain how banker Sir Henry Furnese outperformed his rivals by utilizing and acting upon information that was available to him and enhancing his capacity to make wise business decisions.

Later, in 20th century, BI began to acquire more popularity. Before the emergence of computers, information was kept in physical form. As time went on, computers were invented and storage capabilities were significantly improved. It made possible the collection and analysis of larger amounts of data more quickly. In 1956, IBM created the hard disk drive that was first solely used in the secure confines of data centers before being easily accessible to businesses and homes via PCs. Modern business intelligence was built on top of this technological advancement. In 1958, a paper titled "A Business Intelligence System" was published by Hans Peter Luhn, a German computer science researcher, in an IBM journal. Luhn used the term "Business Intelligence" and presented the fundamentals of a BI system in a very

simple model. After his article was published, he became known as the Father of Business Intelligence because the concepts described in the paper were applied by IBM to develop some of the first real business intelligence systems (https://www.datapine.com/blog/history-of-business-intelligence/, 2017).

Different business applications like SAP and JD Edwards arose in the 1970s that facilitated the entry of data into databases. However, the main issue at that time was that while accessing data from several sources, data retrievers could only get one-dimensional reports where the data view was not consistent. In one database, data would be recorded in a certain way, but in another, it would be entered entirely differently. Ralph Kimball and Bill Inmon were people who invented data warehouses in the 1980s and managed to gather data sources and keep them in one location (https://www.pyramidanalytics.com/blog/business-intelligence-history/, 2016). These data warehouses still had certain difficulties because they were frequently of a very technical nature and to run reports, a costly IT team that was particularly commited to a BI platform was needed. Moreover, reports would frequently take a very long time to complete and could become irrelevant by the time they are finished. Even though business intelligence had advanced significantly, there was still a long way to go. The late 1970s and 1980s were also well-known for the emergence of “green bar reports” that were a part of a new BI technology – DSS (decision support systems) that was the first database management system. These reports were useful for such tasks as payroll processing, inventorying stock items, and reporting a corporation's assets and liabilities. In the late 1970s, a new software called executive information systems (EIS) was also developed that was aimed at simplifying the decision-making process by supplying the most recent and necessary information to the upper management. These systems displayed data in an understandable way using graphical user interfaces. However, due to its limits in being useful, it progressively lost favor.

The 90s, in general, are called the period of “Business Intelligence 1.0” in BI intelligence history and evolution because of decreased costs of data warehouse usage that happened due to increased competition in the sphere. Some new tools like

ETL (extract, transform and load) and OLAP (online analytical processing) were developed in this period to simplify and enhance the process of different queries. These tools were designed to simplify the flow of data inside a data warehouse and helped develop various data visualization alternatives for the data under query, enabling the analysts to draw more accurate conclusions from the data at hand. Enterprise resource planning (ERP) solutions, large management software systems that integrate programs to control and automate many corporate operations, also gained popularity at this time. The first "user-friendly" operating system, Windows 95, was released by Microsoft in 1995, which led to the widespread usage of computers in homes and significantly impacted the way people produced and used data in the decades that followed (https://www.dataversity.net/brief-history-business-intelligence/#, 2023).

BI solutions became an integral part of daily operations of large and medium-sized companies starting from 2000s. Self-service business intelligence tools were created to enable non-technical users to build customized reports and visualizations. These tools helped to eliminate divisions within departments and made data more accessible. This period was also characterized by the emergence of social media platforms and the development of the need for real time data. In 2005, Google Analytics was launched and the term “big data” was first introduced. Companies started looking for alternative methods to deal with the extra storage space and processing power needed to manage this rapidly growing volume of data. Because it was impossible to create bigger, faster computers, employing multiple machines simultaneously became the preferred choice. This is when cloud computing services came to existence. Scaling BI initiatives and working with others on data analysis have become easier with the advent of cloud-based BI tools. The way that data is managed and evaluated has also been transformed by big data platforms like Hadoop and Spark. These platforms enable businesses to store and process data in a distributed and parallel manner, enabling the speedy and effective analysis of enormous amounts of data. The amount of data created has also greatly increased as a result of the expansion of the internet of things (IoT) devices which covers the

network of gadgets, sensors, and other items that are linked to the internet and have the ability to gather and transmit data. These gadgets may gather information on anything from power consumption and traffic patterns to the weather and humidity. A variety of applications exploit the data gathered by IoT devices. IoT sensors, for instance, can be used to track soil moisture levels and crop health, enabling farmers to manage irrigation and fertilization.

BI is still developing today in response to shifting corporate requirements and technology advancements. Because of the popularity and wide usage of social media platforms and mobile devices, data on customer behavior and their social connections becomes more prevalent. The platform, like Twitter, Instagram and Facebook produce vast amount of data that needs to be analized. Businesses and governments are using this data more and more to predict customer preferences and behavior and to create customized marketing and advertising campaigns. Data collection for research objectives, such as tracking the spread of diseases or monitoring environmental conditions, is also done via social media platforms and mobile devices. Because the data generated has different form and complexity in term of analysis, new tools and methods for data analysis are being created to make the analysis process easy and quick.

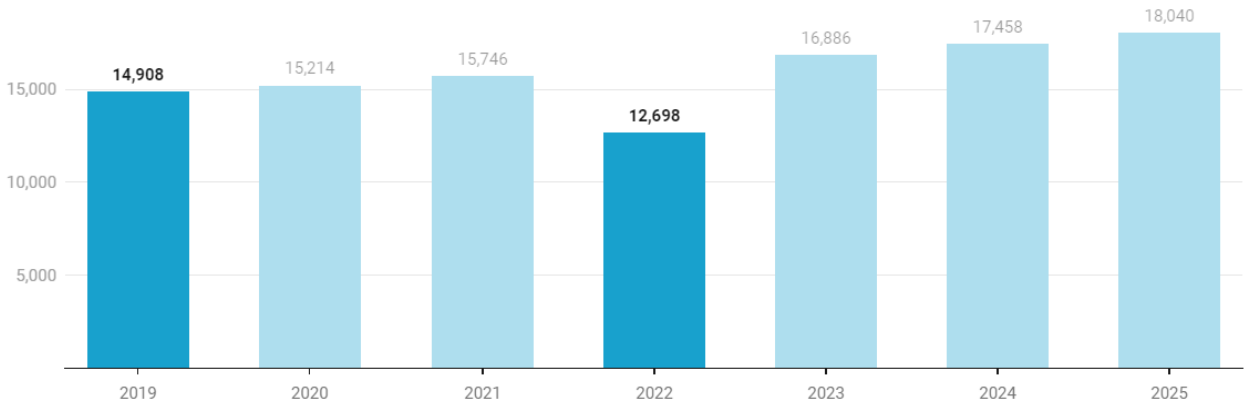
Machine learning (ML) and artificial intelligence (AI) are two examples of these new tools and methods. They are widely being used to evaluate and get insights from unstructured, complicated data sources like photos, videos, and natural language. Patterns and correlations in data that human analysts might not notice can be found by AI and ML systems. Applications for these technologies are numerous, ranging from targeted marketing to fraud detection or healthcare. For instance, AI and ML algorithms can be applied to medical picture analysis to find early disease indications or to create individualized treatment regimens. Privacy and ethical issues are becoming more and more crucial as the amount of data being produced and processed increases. Organizations need to make sure that they are responsibly and ethically gathering, keeping, and using data. In order to safeguard consumer privacy and stop data breaches, governments and regulatory authorities are also taking

action. For instance, the General Data Protection Regulation (GDPR) of the European Union establishes stringent guidelines for the collection, storage, and use of personal data by companies.

1.2. The role of business intelligence in improving the efficiency of companies

In the competitive business environment of today, where businesses must continually respond to shifting market conditions, BI tools and approaches have grown in significance. In 2022, 26% of all the world companies have already

Figure 3. "Business Intelligence and Analytical Software Applications Market Size Worldwide from 2019 to 2025" ($mln)



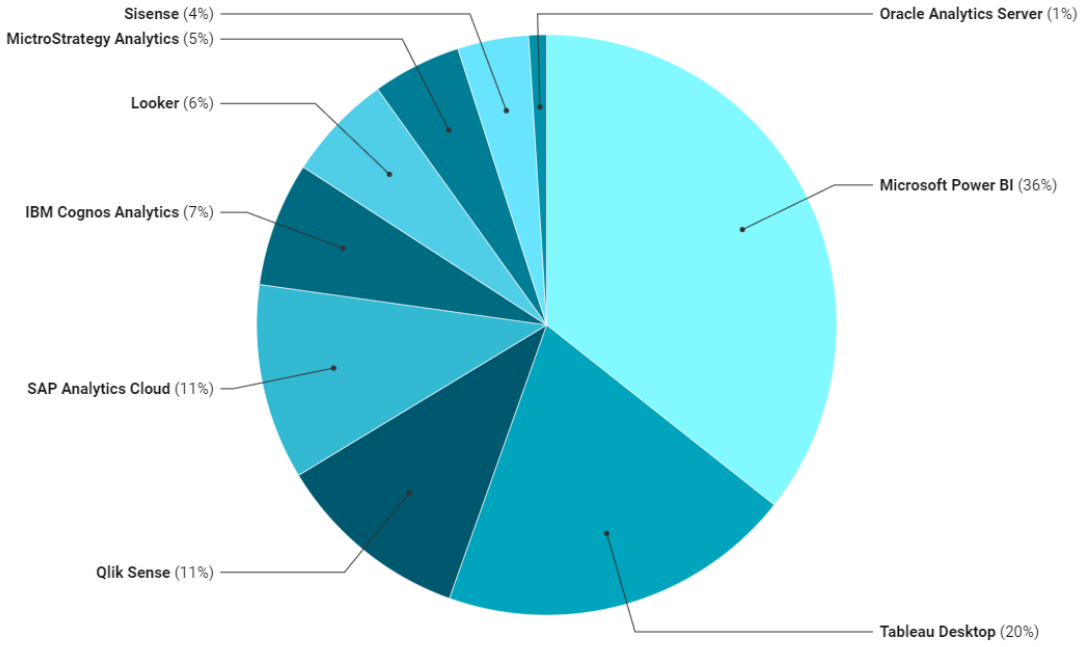
Source: Barry Elad, "Business Intelligence Statistics 2022 – Usage Stat, Employee Data Literacy, Adoption and Jobs Statistics", https://www.enterpriseappstoday.com/stats/business-intelligence-statistics.html, 2022

employed BI tools. It is projected that by 2025, the market for business intelligence will be worth $33.3 million globally (Elad, 2022). According to Figure 3, the market for BI and analytical software tools will increase from 16,886 million in 2023 to 18,040 million by 2025.

The ability for businesses to make decisions based on data is one of the main advantages of business intelligence. With the usage of BI tools, companies can fasten their decision-making process five times. Companies can use data to obtain insights into their business operations, customer behavior, and market trends rather than depending on instincts or assumptions. As a result, they are able to make better decisions and react promptly to market fluctuations. Although the various

information systems may be effective in assisting companies in carrying out particular tasks, they are often not well adapted to provide information to end users.

Figure 4. "Business Intelligence Software Market Share 2021"



Source: Barry Elad, "Business Intelligence Statistics 2022 – Usage Stat, Employee Data Literacy, Adoption and Jobs Statistics", https://www.enterpriseappstoday.com/stats/business-intelligence-statistics.html, 2022

Users will be able to convert this data into knowledge, and knowledge into profit, with the help of business intelligence. There are various BI softwares that are utilized by businesses and the choice of the software depends on many factors, including the benefit that the software will provide and the goal that the firm wishes to achieve at the end. According to Figure 4, Microsoft BI is the most demanded software by the companies as it holds 36% of market share. Tableau takes the second place with the market share of 20%.

The ability to assist businesses in the process of finding operational inefficiencies is one of the most important advantage of business intelligence. Companies can find areas where their procedures can be improved and waste reduced by examining data from multiple sources, such as sales figures, customer feedback, and employee performance indicators. They may find, for instance, that particular personnel are performing poorly and want more training, or that specific goods are not selling well and need to be repositioned. Business intelligence can

assist firms in streamlining their processes in addition to spotting inefficiencies. Companies can improve their pricing strategies, product mix, and marketing efforts by examining data on sales patterns, customer preferences, and other factors. Along with higher customer satisfaction, this may result in higher sales and profitability.

Businesses can enhance their supply chain management with the aid of business intelligence. Companies can leverage their supply chain operations to lower costs and accelerate delivery times by examining data on inventory levels, shipment durations, and other factors. This can assist them in satisfying consumer needs more efficiently and enhancing their level of market competition. Business intelligence can also aid organizations in developing a deeper understanding of their clients. Businesses may create more individualized customer experiences and more focused marketing efforts by evaluating data on client behavior, tastes and comments. In addition to increasing revenue and profits, this may also boost client retention and commitment.

Business intelligence helps the companies to gain competitive advantage, capture bigger market share and increase revenue. BI gives the companies the tools they need to monitor, analyze, and manage their operations in order to improve overall business performance. Businesses can increase operational effectiveness, create valuable customer relationships, and create unique product offerings with the help of BI. The benefits of employing business intelligence are innumerable due to its broad applicability. Carver and Ritacco in their “Framework for Measuring the Benefits of Business Intelligence” highlight three primary categories of BI benefits. These are lowering costs, increasing revenue, and improving customer satisfaction (Carver & Ritacco, 2006: p. 9).

The introduction of BI lowers organizational costs because it improves operational efficiency by giving customers access to real-time data over the intranet and extranet where customers can monitor their own accounts and find answers to their own inquiries. They can also contribute to data cleansing process by reviewing and fixing inaccurate information about them in the system themselves. Additionally, BI eliminates reporting delays by allowing the users to create their

own reports and queries. This eliminates the need to employ special IT staff for this work and leads to considerable reduction in labor costs. BI also ensures negotiation of better contracts with suppliers and customers by examining supplier performance, including trends in on-time delivery, the percentage of rejects, and pricing variations. Getting access to this information puts a company in an exceptional position to discuss all parts of the contract and perhaps negotiate bulk reductions. Moreover, BI helps to uncover and address the fundamental causes of issues by asking question "Why?". Once a thorough understanding of the underlying reasons of the problems reached, efficient actions can be taken. Finally, BI can lower costs by finding wasted resources to cut inventory costs and allocating saved resources to highly profitable products, customers, and projects (Carver & Ritacco, 2006: p. 9-11).

Utilization of BI system increases a company's revenue through analysis of customer behavior patterns and creation of special offers customized to the needs and wants of the buyers. Better access to all the data company generates on a daily basis allows marketers to get solutions to the most specific queries. They can measure a success of the specific promotional campaign, find out which product offered by the company is the most popular among customers, segment their markets and gain a competitive advantage over the rivals. Moreover, product launches and advertising campaigns can be precisely tailored by the marketer to the intended audience. Additionally, the performance of the company can be further improved if the results achieved are compared to the past and thoroughly analyzed. The company can focus on highly profitable clients and products to maximize the revenue (Carver & Ritacco, 2006: p. 12-13).

The third primary category in which employing BI benefits an organization is improved customer satisfaction. An easy access of employees to the information of the company allows them to make better decisions in a shorter time without raising a particular question to the management and wasting time on receiving the answer. Since choices are made by those who are immediately involved in the activities, this ensures practical and efficient responses. Additionally, employees are more satisfied

and motivated because they are in charge of their own process and enjoy certain freedom in their actions. BI also provides an opportunity to businesses to challenge their assumptions with factual information they get as a result of data analysis. A lot of firms base their predictions about future performance on assumptions which are not always correct. Checking the validity of these assumptions and acting upon errors identified ensures high quality of the goods and services provided to customers (Carver & Ritacco, 2006: p. 13-14).

However, as any technological advancement, the establishment of BI system involves significant costs. Whether these costs are justifiable or not should be analyzed before the decision on introducing BI is made. Multiple quantitative and qualitative approaches for assessing investments can be observed in both academic research and commercial practice. When addressing how to analyze investments in business intelligence and information technology, aproaches based on qualitative analyses are particularly important. Several methods for evaluating an investment include ROI - return on investment, NPV - the net present value, IRR - internal rate of return, cost-benefit analysis, and TCO - the total cost of ownership, case study, and subjective evaluation method (Hočevar & Jaklič, 2009: p. 101-102).

Moss and Atre highlight four components which should be taken into account while justifying the investment in business intelligence. The components include business reasons for investing in business intelligence, the information required for business analysis, cost and benefit analysis of BI system and risk assessment. They suggest that the BI solution's objectives must coincide with the business's strategic goals and that it is necessary to identify the data required for reaching strategic objectives and for making decisions. Tangible and intangible benefits as well as any risks of BI must be taken into account and compared to the implementation costs (Moss and Atre, 2003: p. 31). It is very difficult to measure all the benefits of introducing BI system because some of the benefits are not financial, unpredictable and intangible. Even if we consider that such benefits should result in financial outcomes such as cost savings, the collection of information through BI and the associated financial gain may take some time as there is a time lag between

implementing BI solutions and receiving the results (Lönnqvist & Pirttimäki, 2006, p. 34). Nevertheless, Carver & Ritacco (2006: p. 15) suggest a way how investment in BI can be justified by breaking down its benefits into four categories: quantifiable benefits, indirectly quantifiable benefits, unpredictable benefits, intangible benefits. They then advice measuring total cost of ownership (TCO) of BI and then comparing it to the value of quantifiable benefits and indirectly quantifiable benefits. If TCO is less than quantifiable and indirectly quantifiable benefits, the system is definitely worth the cost. If TCO is more, then the evaluation of the unpredictable and intangible benefits is necessary to make the right decision.

A case study is another method that can be used in assessing the justification of investment in BI. In this method, a specific case is deeply and extensively studied by investigating a real-world example. It may involve a mix of qualitative and quantitative studies depending on the specifics of the case study. The technique takes a very thorough and methodical approach to measuring the value of information technology investments in general, but it does not specifically address the evaluation of business intelligence investments.

Finally, a method called subjective evaluation is based on user observations and can reasonably correctly depict the results of business intelligence. From one perspective, it demonstrates how users benefit from business intelligence solutions, but from another perspective, this method fails to present any proof of the monetary worth of the results of an investment in information technology (Hočevar & Jaklič, 2010: p. 103-104).

CHAPTER II. THE EFFECT OF DEVELOPMENT OF DATA VISUALIZATION METHODS AND TOOLS ON BUSINESS INTELLIGENCE

2.1. Data visualization methods in Business Intelligence

BI outcomes are typically displayed in reports, dashboards, and analytical tools that are primarily driven by data visualization. This chapter offers a thorough analysis of these visualization methods that aid BI managers, decision-makers, analysts, and developers in making better choices and better decisions. The goal of using data visualization is to help users to easily comprehend and interpret the information, facilitate decision-making process and enhance problem-solving capabilities. Visualization tools and forms utilized in BI reporting and analytics can

Table 1. "Common Forms of Business Data Visualization"

Form/Style	*Description*	*Typical Types and Examples*
Embedded visual	It is embedded in, or directly on top of, texts and other forms of data presentation (tables, graphics, etc.).	• Conditional formatting • Inline chart (Sparkline)
Block visual	It is displayed as an independent visual unit and occupies a larger space. It is often a part of a report or dashboard, appearing together with other content. But sometimes it can become a standalone visual with many data points or enough complexity.	• Chart • Illustrational diagram • Map (smaller) • Data table (usually with embedded visuals)
Standalone visual	It is a standalone application and is not mixed with other types of content or tools. Most interactions are within the visual. It may consist of a combination of different types of visuals.	• Dashboard • Visual analysis tool (or an analytical dashboard) • Map (bigger or full screen)

Source: Jack G. Zheng, "Data Visualization in Business Intelligence", https://www.researchgate.net/publication/321804138_Data_Visualization_for_Business_Intelligence, 2018

be categorized into common groups.

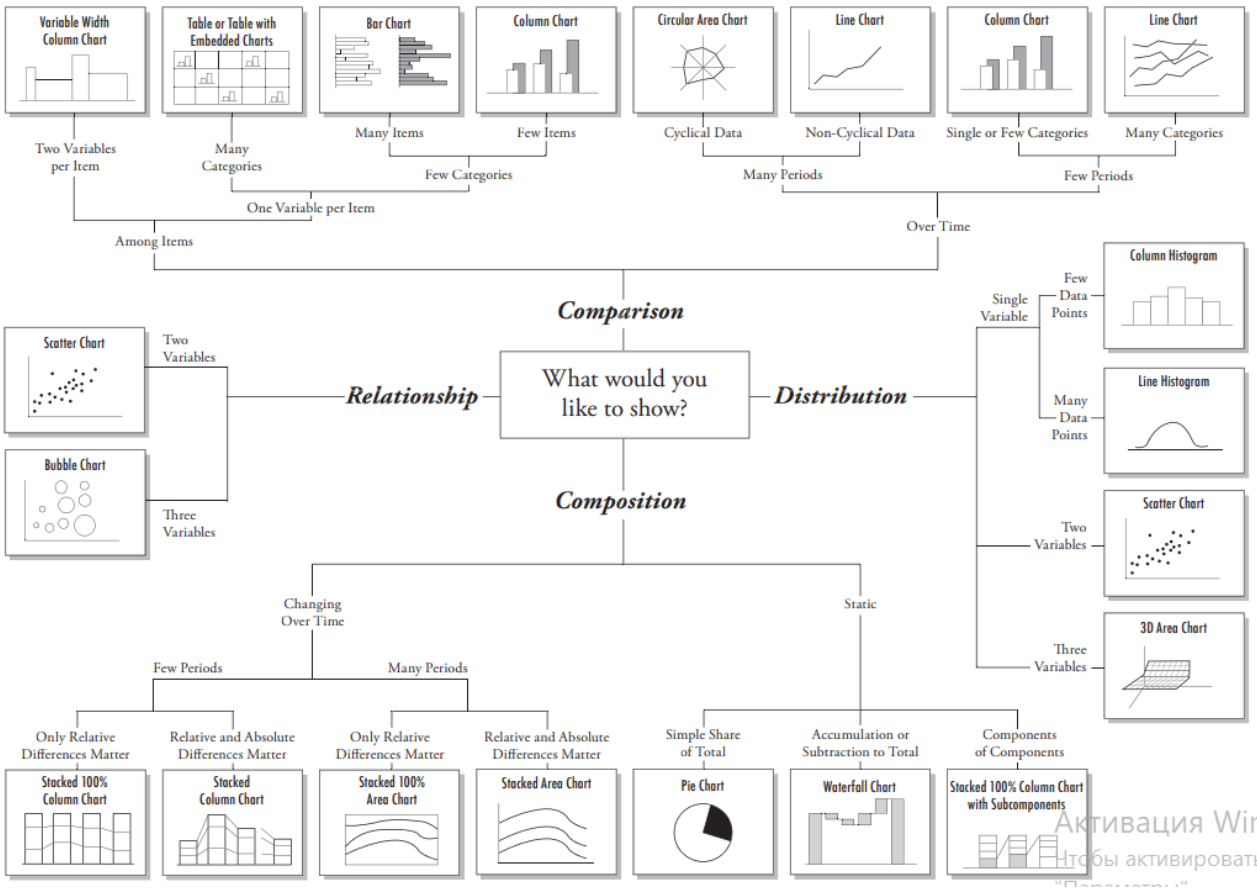
Based on how visualizations are displayed on screens, Jack Zheng (2018), Associate Professor of Information Technology at Kennesaw State University, suggests that there are three fundamental categories of visual forms: embedded visuals, block visuals, and standalone visuals. Characteristics and examples of each of these categories are described in Table 1. Embedded visuals, which are of two main types, conditional formatting and inline mini charts (or Sparkline), are never used alone; rather, they are always layered on top of other presentation formats and can be integrated into any software application, the cloud, or a standalone app. Conditional formatting helps to draw attention to a certain passage of text or piece of data without altering the structure and organization of the information. A Sparkline is a tiny, minimized chart that is inserted into the body of text, tables, images, or other types of content that offers simple visual information about the data. It does not contain any supportive information in the form of title, legend or label. Although examples include bar charts, bullet graphs, etc., the most widespread type of the chart utilized is a line chart.

Block visuals are more independent types of visualization and can sometimes appear as standalone visuals, but in most of the cases, they are a part of a larger content. The two types of block visuals that are most frequently used are charts and diagrams which are very similar in nature and can sometimes be used interchangeably. However, a small difference between these two visualization types exists and this difference is that charts are mostly used to visualize quantitative data, whereas diagrams can also be used to visualize qualitative data. Examples of charts are line charts, histograms, bar charts, pie charts, while examples of diagrams are tree diagrams, Venn diagrams, network diagrams, etc.

Standalone visuals compared to the embedded and block visuals take up significantly more room or perhaps entire screens and resemble apps more than they do visualizations. A main type of standalone visuals is a digital dashboard. A dashboard is not a particular type of data or piece of technology, but rather a display or presentation style that offers visibility into KPIs using straightforward visual illustrations like gauges, charts, and tables within a web browser. A dashboard is a

visual representation of the most crucial data required to accomplish one or more goals, collected and organized on one screen for easy monitoring (Few, 2004). It is comprised of metrics (numerical values measuring different aspects of business activities), KPIs (a measurable indicator of performance over time for a certain goal) and other values that reflect on comparisons and relationships like distributions and forecasts. Dashboards, if well-designed, enable business owners to view business state through the utilization of the most relevant data and help in decision-making process. It saves the user time by removing the need to run several reports or obtain data from various sources and make it possible to comprehend facts in a short period of time and react swiftly at one place.

Figure 5. Types of Charts Suggested for Use

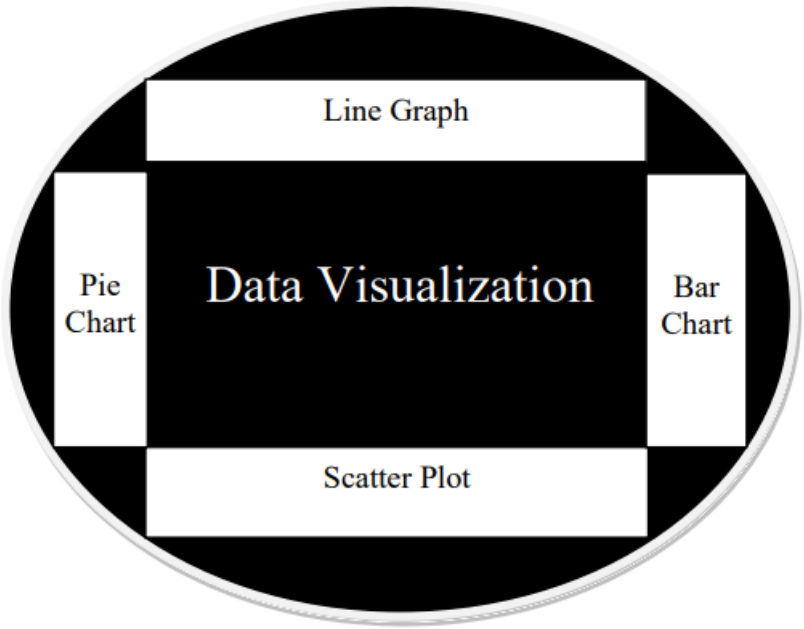


Source: Dr. Andrew Abela, “The Extreme Presentation Method”, 2008

Dr. Andrew Abela who is the founding Dean of the Busch School of Business at the Catholic University of America in Washington, designed the Extreme Presentation Method for successful conveyance of complicated information. Among

all the other useful information, he provides a simple classification of charts according to their intended usage (Figure 5). Abela's visual guide has been extensively utilized by many users as a guidance in chart selection (Abela, 2008). However, the charts that are illustrated in Figure 5 are not the only ones that exist. There are a lot of other visualization methods available and the choice of method will depend on the data being analyzed, the purpose of the visualization, and the audience. Some of the charts and diagrams are more common (Figure 6) and therefore, deserve a special attention and will be described in more details in the following paragraphs.

Figure 6. The Most Popular Data Visualization Techniques

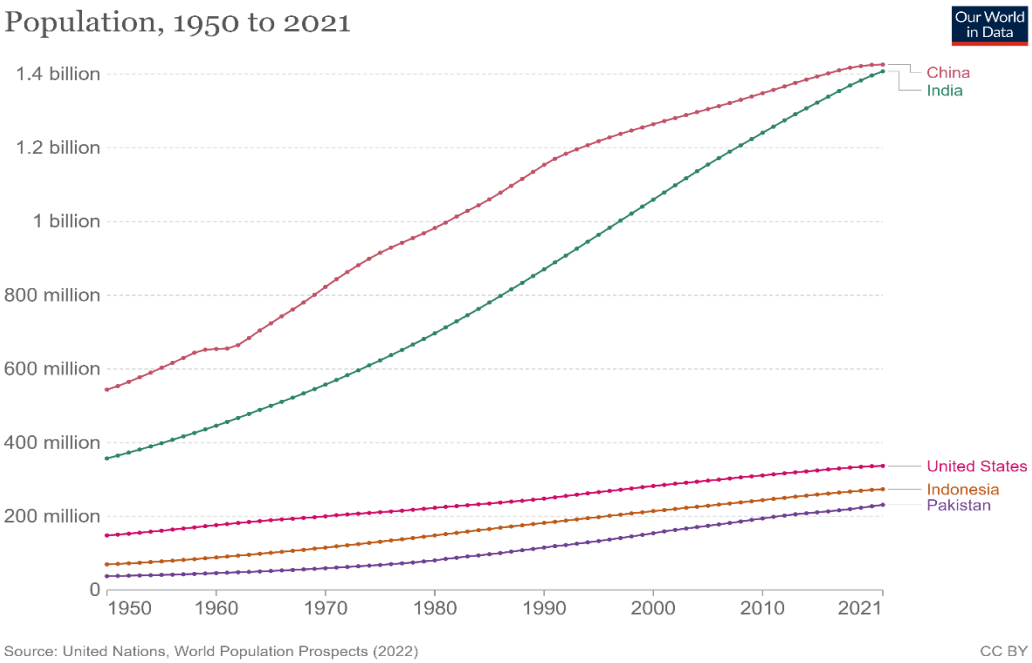


Source: Matthew N. O. Sadiku and others,"Data Visualization", https://www.researchgate.net/publication/311597028, 2016

- **Line charts**. Line charts are created by plotting a series of several points and connecting them with a straight line. They depict the relationship between different variables and often used to compare many items at once (Ajibade and Adediran, 2016, p. 107). The stacking lines on the chart show and compare the trends for various variables over time. The horizontal axis usually shows a time frame, like minutes, hours, days, months or years, while the vertical axis displays the numerical variables, like earnings, sales, population, etc. This

visualization type is usually used to monitor changes over both short and long time periods. Figure 7 is an example of a line chart used to show the changes in world population over the time frame between 1950 and 2021 in 5 different countries. We can easily analyze and identify that population has significantly increased over the time period under consideration and that China and India were the main countries which contributed towards this increase.

Figure 7. World Population Growth

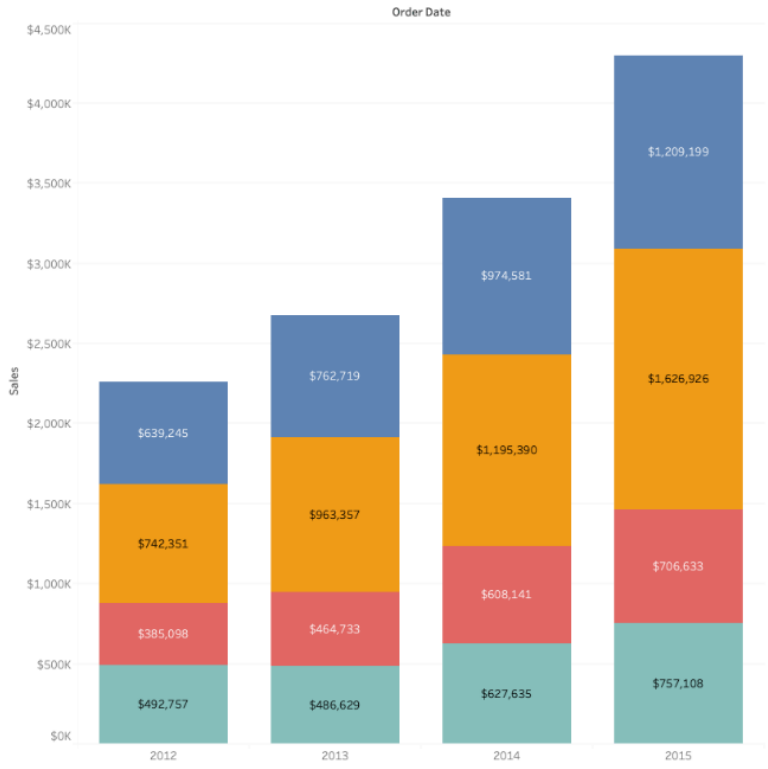


Source: Max Roser and others, "Our World in Data", https://ourworldindata.org/world-population-growth, 2013

- **Bar charts.** Bar charts, also known as column charts, are employed for contrasting items belonging to various groups using both horizontal and vertical bars to illustrate the different values of a group (Ajibade and Adediran, 2016, p. 108). Usually, on one axis the quantitative values and on the other axis qualitative values are displayed. The design will depend on the type of data and issues the visualization attempts to solve. In most cases, the starting value of a bar chart is zero and if a different beginning point is chosen, the axis should be clearly identified to avoid confusion of the viewer. The types of bar charts vary and they can demonstrate how well various approaches or techniques work in achieving the goal and compare different values in

subcategories. For example, the bar chart that is illustrated in Figure 8 represents the amount of sales of four different products over four years. As we can easily notice, the year that experienced the highest and the lowest amount of sales is 2012 and 2015, respectively. In 2012, the total sales were $4,299,866 while in 2012 the value was $2,256,451. The product that contributed the most to high sales in 2015 is depicted with orange color and brought to the company sales in the amount of $1,626,926. The company's managers can easily get this information by just looking at the graph and utilize it while making decisions on types of promotional campaigns to be introduced and which products these campaigns should target. They can also decide which product's production should increase and which should be withdrawn from sales.

Figure 8. "Sales by Order Date"

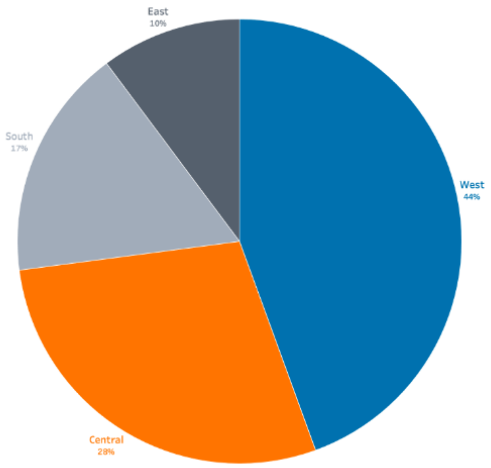


Source: "Understanding and Using Bar Charts". https://www.tableau.com/data-insights/reference-library/visual-analytics/charts/bar-charts

- **Pie charts**. The pie chart that is also referred to as a circle chart, splits the circular statistical visual into sectors or portions like slices of a pie. Each sector represents a part of the whole and forms a specific proportion. The pie

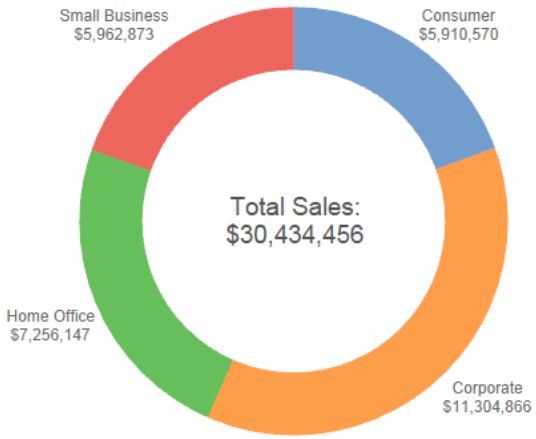
chart totals to 360 degrees or 100% if data is represented in percentages. To make it more comfortable for users to read a pie chart, it should contain some text to explain the content and the sectors should be represented in

Figure 9. % of Total Sales per Market for Small Market Sizes



Source: "Understanding and Using Pie Charts", https://www.tableau.com/data-insights/reference-library/visual-analytics/charts/pie-charts

Figure 10. Doughnut Chart Illustrating Shares of the Total Sales

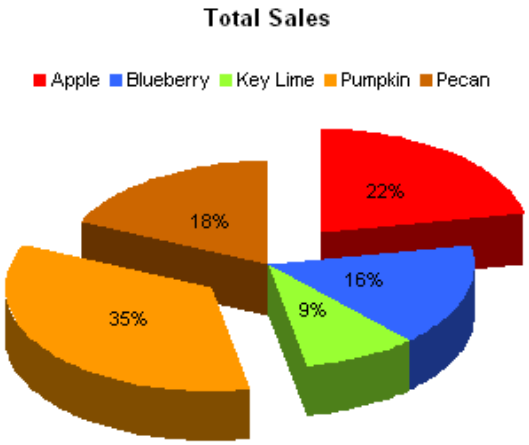


Source: Tom McCullough, "The Tableau Cookbook: Donut Charts", https://interworks.com/blog/tmccullough/2014/03/06/tableau-cookbook-donut-charts/, 2014

percentages. Pie charts have two widely used variations which are doughnut chart and exploding pie chart that can contain more than one data series. A doughnut chart, for example, illustrates data with rings and has a hollow center, whereas an exploding pie chart shows the contribution of each value to the whole while stressing the importance of each item individually. The

examples of each type of pie chart are provided in the figures above. Figure 9 illustrates a standard pie chart, Figure 10 – a doughnut chart and Figure 11 – an exploded pie chart.

Figure 11. Exploded Pie Chart Highlighting Some Segments of the Chart

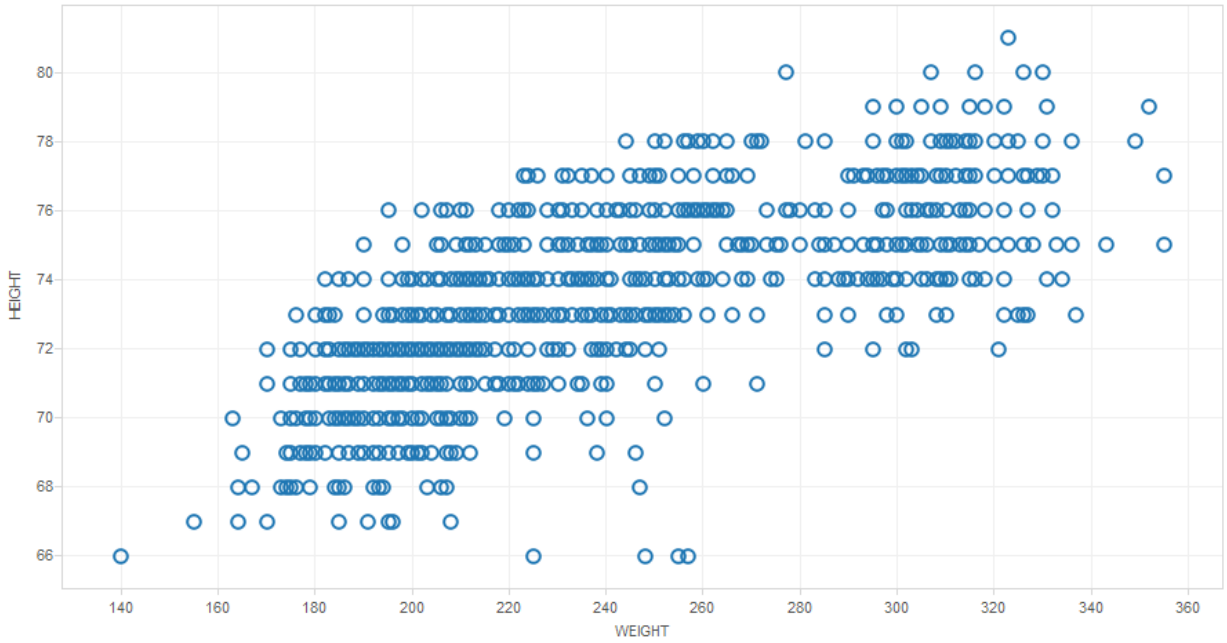


Source: Jon Peltier, "Exploded Pie Chart Replacement", https://peltiertech.com/exploded-pie-chart-replacement/, 2009

- **Scatter plots.** A scatter plot, sometimes referred to as a scatter chart, is a graph that displays the correlation between two variables. The majority of scatter plots are used in science journals and publications. It is a very effective type of chart because it enables people to see relationships or trends that would be very difficult to see in any other form right away. Scatter plots help the users to spot anomalies in the data, to identify how one variable affects another and recognize a correlation, pattern, trend, or relationship. The 17th-century cartesian coordinates system developed by René Descartes is the foundation for current scatter plots. The way the scatter plot works is that it has the dependent variable shown on vertical y-axis and an independent variable shown on horizontal x-axis. In order to show the intersection of the two coordinates, an even scale is first constructed on both axes, and then a mark or dot is placed there (Curtis, 2014). Figure 12 represents an example of a scatter plot where the relationship between height of a person and his weight is depicted. We can clearly notice that there is a positive linear relationship

between these two measurements.

Figure 12. A Scatter Plot Illustrating the Relationship Between the Height and Weight



Source: Robert Curtis, "Tableau Essentials: Chart Types – Scatter Plot", https://interworks.com/blog/2014/11/21/tableau-essentials-chart-types-scatter-plot/, 2014

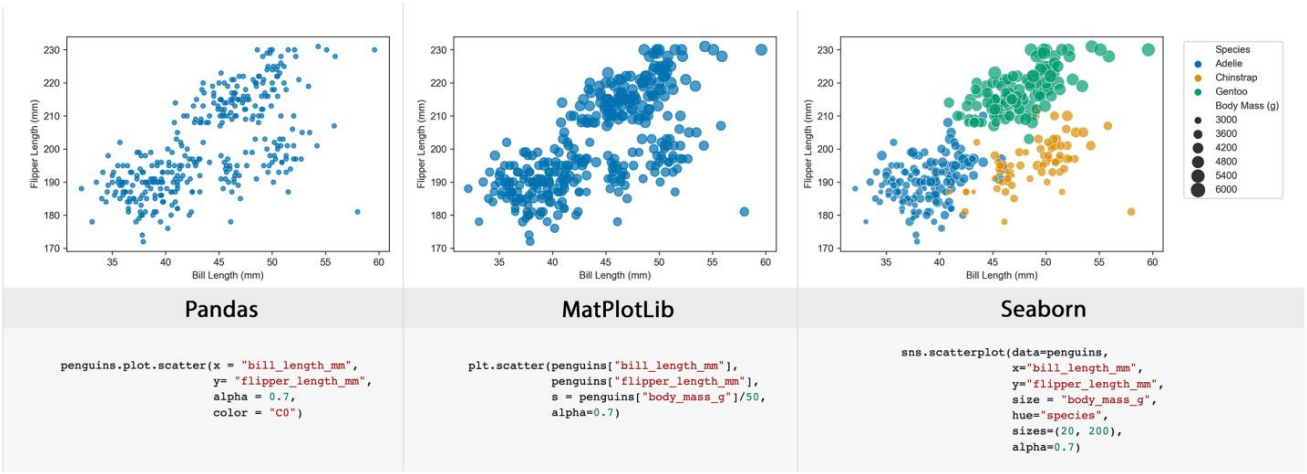
2.2. Data visualization tools and libraries in Business Intelligence

There are many data visualization tools and libraries available for Business Intelligence. Some of the most popular tools include Tableau, Power BI, QlikView, Google Charts, and programming languages Python and R. Some of these are free, open source software programs, like Python and R, others have free and paid options depending on the purpose of use. All the tools mentioned above will be analyzed in details below.

- **Python**. Being now ranked first on the TIOBE index (2023), it is one of the most widely used programming languages in the world, topping the IEEE Spectrum 2022 programming languages list (Cass, 2022). A large portion of NASA's space exploration program, as well as websites like YouTube, Dropbox, and Reddit, are powered by the Python programming language. Python's success may be largely ascribed to its ease of use. Its open-source nature has resulted in a huge, engaged community of programmers of all levels

of expertise with an abundance of examples, instructions, and solutions easily accessible online. One of the characteristics that make Python so popular is its external libraries that can be incorporated as needed to broaden the language. This enables the further simplification of code in addition to keeping the main language concise and simple to understand. The libraries in Python are available for almost anything and some of the examples include Pandas, Seaborn, MatPlotLib, and Plotly. There are certain differences between these three libraries. Pandas allows the users to first explore and analyze the data and gives access to useful data structures, like DataFrames, while MatPlotLib and Seaborn are specifically tailored for data visualization. MatPlotLib enables fundamental data visualization, whereas Seaborn adds additional visualization techniques that enhance the examination of statistical data on top of MatPlotLib. The examples of visualizations created using each of the Python

Figure 13. Three Scatter Plots Produced by Three Popular Python Libraries for Data Visualization



Source: Annabel Cansdale, “How Exploring Python Can Level Up Your Data Visualization”, https://www.researchgate.net/publication/354733989_How_exploring_Python_can_level_up_your_data_visualization, 2021

library provided in Figure 13. As can be seen, Seaborn provides more informative visualization because it makes more simple to encrypt additional details into one plot, while also enabling the plots created to be visually beautiful and unified. Although Seaborn is generally more siutable library while creating publishable figures, users, sometimes not even noticing, utilize

all three libraries when visualizing their data. Every visitor can choose, sort, zoom, and examine the data as they desire using another library called Plotly, which enables interactive visualizations. These visualizations can be created locally and then shared online with the general public. Table 2 summarizes the characteristics of each of the Python's library that were discussed in this paper (Cansdale, 2021).

Table 2. "Comparison of Python Libraries for Data Visualization"

Pandas	▶ Used primarily for data analysis ▶ Basic plotting function, useful for quick visualizations
MatPlotLib	▶ MATLAB-style syntax ▶ Heavily customizable ▶ More input needed to produce publication-ready figures
Seaborn	▶ Builds on MatPlotLib – adding themes and advanced plotting styles with a simpler syntax ▶ Easy to make publication-ready figures
Plot.ly	▶ Create interactive plots to explore data ▶ Deploy these plots to the web as dashboards to easily allow others to explore data

Source: Annabel Cansdale, "How Exploring Python Can Level Up Your Data Visualization", https://www.researchgate.net/publication/354733989_How_exploring_Python_can_level_up_your_data_visualization, 2021

- **Tableau**. Being one of the most popular tools for data visualization, Tableau provides interactive visualization services to large number of businesses. It effectively generates visuals and graphics from sizable, dynamic datasets used for artificial intelligence, machine learning, and Big Data applications by offering integration for sophisticated databases like Teradata, SAP, My SQL, Amazon AWS, and Hadoop. It assists in reducing raw data to a format that is very simple to interpret and enables non-technical users to design unique dashboards because it does not require any prior technical or programming knowledge. Tableau offers several product options, some of which are free, while others are paid. For example, Tableau Desktop, Tableau Server, and Tableau Online are paid, while Tableau Public, Tableau Reader and Tableau Mobile are available to the public free of charge. The main difference between paid and free product suite is that free options do not allow the users to save their workbooks on their own computer. Instead, they can save them to

Tableau's public cloud where everyone can access and download the files. As every product, Tableau also has its own positive and negative sides and the decision on whether to choose this software depends on the company's budget, type of data analzyed and the type of visualization that is required. One of the advantages of Tableau is that it provides a high illustration and design quality that is superior to what its competitors offer. It changes messy statistical data into detailed, insightful findings that are completely operational and interesting dashboards which are easy to use in commercial activities and come in a different graphic forms. The tool also responds quickly even when dealing with large amounts of data. Tableau connects with such data sources like Hadoop, SAP, and DB Technologies that allows it to enhance the quality of data analyses and makes it possible to create a uniform, educational interface. Finally, Tableau is mobile-friendly giving its customers greater flexibility and easy access to the statistics. The main negative side of this data visualization tool is that it is costly for small and medium companies to purchase it. Tableau is not as expensive as products from industry leaders in business intelligence, like Oracle and IBM, but it needs appropriate employee training, deployment, and maintenance, all of which are expensive. Because of this, Tableau is mostly preferred by big companies. Additionally, Tableau's pricing model is inflexible as it offers only one extended license regardless of the fact that companies have their own specific visualization requirements and may not utilize all the features the software offers. There are also some issues with data security and after-sales support which make this data visualization tool not suitable for all the companies (Shaptunova, 2023).

- **Programming Language R.** R is one of the programming languages that's frequently employed for data analysis and data visualization. It is an open-source software that is user-friendly and is flexible in data manipulation. Because of these features, it has gained popularity in recent years. R offers a wide range of tools and libraries, like ggplot2 and lattice for the generation of engaging and exceptional visualizations. R's capacity to manage massive

databases is one of its primary characteristics as a data visualization service. Several R libraries can be used to generate sophisticated visualizations from huge data sets. R can also receive data from numerous sources, such as CSV files, Excel spreadsheets, and SQL databases and it is adaptable in the creation of custom visualizations. R provides a substantial library of functions and instruments for the creation of customized visualizations, enabling users to create new and distinctive visualizations. Additionally, the R programming language is highly flexible, permitting the development of further packages and libraries that can be utilized to broaden its capabilities. One of the benefits of using R as a data visualization tool is its compatibility with other data analysis applications. R can be combined with other programming languages, such as Python and SQL, to create an extensive workflow for data analysis and visualization. In addition to its data visualization capabilities, R offers an array of statistical functions and instruments. There are, however, some disadvantages associated with employing R as a data visualization tool. A major obstacle is the severe learning curve needed for successful use of R. R necessitates a solid comprehension of the basics of programming, which can be difficult for people with no prior knowledge in programming. Moreover, despite the fact that R is an effective data visualization tool, it might not be the most effective option for producing real-time or interactive visualizations due to its slower performance. Despite these obstacles, R is widely employed by businesses for data visualization.

- **PowerBI.** Businesses frequently utilize Power BI, a data visualization application, for business intelligence and data analysis. It is a Microsoft application that offers a user-friendly interface for developing dynamic dashboards and reports. Power BI is widely recognized for its simplicity, adaptability, and capacity for handling huge datasets. The capacity of Power BI to manage huge datasets is one of its key features. Excel spreadsheets, SQL databases, and cloud-based storage systems like Azure and Amazon Web systems are just a few of the sources from which Power BI can read data from.

Additionally, it offers a number of tools for data conversion, including Power Query and Power Pivot, that let users work with and change data before producing visualizations. The simplicity of usage of Power BI is another feature. With the help of Power BI's drag-and-drop interface, users can build dashboards and visualizations without being to have a deep understanding of programming. Additionally, it offers a selection of pre-built visualizations that can be altered to meet particular needs, including tables, charts, and maps. The compatibility of Power BI with other Microsoft products is a benefit of utilizing it as a tool for data visualization. Power BI has integrations with Excel, SharePoint, and other Microsoft tools that make it easy to collaborate and combine data. To protect data security, Power BI also offers a range of security capabilities, including role-based access control and data encryption.
However, using Power BI as a tool for data visualization has some drawbacks as well. The price of employing Power BI is one of the biggest obstacles. Despite having a free version, Power BI Pro and Power BI Premium require a monthly or annual subscription. Furthermore, Power BI might not be the best option for developing highly customized visualizations because doing so might necessitate a significant amount of modification and development work. Despite these difficulties, businesses frequently use Power BI for data visualization.

- **QlickView**. A data visualization tool called QlikView is made to assist enterprises in making data-driven choices. Users can construct interactive dashboards and reports as well as examine correlations between different data sets and visualize data from various sources. The in-memory data processing capabilities of QlikView are one of its primary features. This enables quicker analysis and visualization of data since data is transferred into memory rather than read from a disk. Another special feature of QlikView is "associative data indexing," which enables users to investigate connections between different data sets and move promptly between related data points. The flexibility of QlikView is another important feature. In order to fulfill their particular

requirements, users can develop customized calculations and phrases, as well as unique data models and visualizations. Additionally, a variety of chart types are available in QlikView, including bar charts, line charts, scatter plots, and heat maps.

The simplicity of usage of QlikView is one of its main advantages. Users can easily build visualizations and reports using its straightforward drag-and-drop interface without the need for sophisticated coding or programming. Additionally, QlikView has a vibrant user and developer community that offers a wealth of information and assistance to users.

Nevertheless, there are some drawbacks to using QlikView. A common complaint is that the license can be costly, especially for larger enterprises. Another complaint is that the tool can be resource-intensive, requiring a lot of computer power and memory to handle big data sets. Despite these difficulties, businesses frequently use QlikView for business intelligence and data visualization.

The decision on the choice of a data visualization tool is heavily influenced by the unique needs of a company, including the complicated nature and amount of data being studied, the technical expertise of users, and the budget available for buying and maintaining the tool. In addition, companies may have different requirements for information management and security, which may also affect the data visualization tool they choose. For instance, a company with massive and sophisticated data collection would profit from using a platform like Tableau, which offers extensive data visualization capabilities and can manage huge data volumes. On the other side, a smaller company with fewer resources may choose a more straightforward product like Google Data Studio because it is cheaper and easier to use. A technology like QlikView, which offers strong data security capabilities and enables centralized control of data access and permissions, may also be chosen by enterprises that place a high priority on data governance and security. For businesses in regulated sectors like finance and healthcare, QlikView

additionally provides features like data lineage and auditing. In the end, the selection of a data visualization tool is influenced by a number of variables that are particular to each company and use case. Different tools should be compared for their features, capabilities, and costs as well as for how well they meet the objectives and demands of the company.

- **Google Charts**. Users can build a broad spectrum of dynamic visualizations using Google Charts, which is a component of the Google Developers platform. It is a free online data visualization tool utilized by both companies and consumers to build data-driven visualizations for websites, applications, and other digital projects. Google Charts are easy to use because they are created to be user-friendly even for individuals with little to no prior knowledge of data visualization. Users can quickly and easily generate charts and graphs using the tool's user-friendly interface. Due to the fact that it is a free product, it is an excellent option for businesses with tight budgets. There's no need to spend money on pricey software or solutions when Google Charts offers so many features and capability. It is also adaptable since a variety of modification options, such as colors, fonts, and styles, are available. This enables businesses to construct charts and graphs specifically for their branding and design requirements. Additionally, Google Charts offers a high level of interaction, enabling users to zoom in and out, move over data points for more details, and choose various data sets for comparison. This makes it simple for consumers to explore and evaluate data in a more meaningful way. Last but not least, Google Sheets and Google Analytics may both be readily integrated with Google Charts. This enables businesses to access and analyze data from a variety of sources using a single platform.

2.3. Importance of Data Visualization for Businesses, its aplications and challenges

The emergence of big data has changed how businesses function, producing enormous volumes of data that can be utilized to support strategic planning and

decision-making. Data visualization provided tools to analyze and present this data which, otherwise, would be overwhelming and challenging to interpret. Businesses can utilize data visualization as a powerful tool to turn complex data sets into understandable visuals that can be used to guide decisions. Visualization tools are especially helpful when determining the connections between various variables as well as the effects of certain choices and actions. As businesses attempt to gain an advantage over their competitors by utilizing the enormous volumes of data they generate, the usage of data visualization has grown in popularity. The size of overall data visualization market was estimated at USD 6065.4 million in 2022 and is projected to increase at a compound annual growth rate of 9.36% from 2022 to 2028, totaling USD 10374.44 million (Yen, 2021). There are many reasons for data visualization to be important for businesses, but this paper will outline some of them.

To begin with, usage of data visualization tools can help businesses to easily spot patterns, trends, and insights and enhance strategic planning by identifying correlations, dependencies, and other relationships that could go unnoticed in more conventional textual or tabular formats. This helps the firms to make better judgments and become more competitive than their rivals. Utilizing visualization tools, businesses can better understand how their operations are going and spot potential areas for expansion. As well as predicting upcoming market trends and developments, it assists in locating areas that require investment and improvement. To enhance strategic planning, companies can define key performance indicators (KPIs) and track them over time by visualizing their data. They are able to quickly spot trends and patterns that are applicable to their industry and change their plans as a result. A company might, for instance, evaluate customer satisfaction levels over time, determine the areas where satisfaction is low, and then take steps to enhance the consumer experience. Accenture conducted a survey among 900+ financial professionals, including CFO's and found that 81% of respondents were supporting the idea that data storytelling is an essential ability for every finance practitioner (Accenture, 2018).

The second reason of the importance of data visualization is improved

communication because visualization technologies aid in conveying complex facts in a clear and concise manner. Companies can more effectively convey complicated information to stakeholders, such as employees, investors, and consumers, by displaying data in a visual style. This can foster cooperation and teamwork, as well as increase trust and transparency. A company might, for instance, use a visualization tool to plot sales data in a graph or chart so that staff members can see which goods and services are being purchased well and which are not. Furthermore, data visualization can enhance collaboration inside organizations by offering a universal visual language for addressing large data sets. This can enhance teamwork and guarantee that everyone in the company has a clear knowledge of the data.

The third reason is that data visualization allows companies to make better decisions and improves efficiency. It helps to determine a problem's root causes, forecast future trends, and pinpoint areas in need of improvement. It also provides insights into the data and helps businesses to save time and effort needed for data analysis by presenting data in an easy-to-understand format. This facilitates quicker and more effective decision-making for enterprises. In addition, businesses can immediately spot patterns and trends by offering a visual representation of the data instead of having to spend hours reading over spreadsheets and charts. This can save time that could be better spent creating innovative goods or services, fostering stronger bonds with clients, or carrying out market research. Moreover, by optimizing the data analysis process, data visualization can boost productivity and businesses may easily find insights and make sound decisions.

The utilization of data visualization has become a crucial instrument for enterprises and institutions to comprehend substantial amounts of data. Data visualization technology has grown in popularity recently because it makes it possible to portray complex information in a way that is simple to understand. Data visualization has diverse applications in a variety of fields, ranging from financial industry to library management. Finding trends and patterns in big datasets is one of data visualization's most popular applications. The utilization of visualization tools can facilitate the identification of correlations and outliers, enabling businesses to

detect trends that may have been inconspicuous at first glance. Data visualization can also be utilized for the purpose of performance management. Taking advantage of visual representations to monitor key performance indicators (KPIs) enables enterprises to promptly discern their areas of proficiency or those that require enhancement. Usage of data visualization in predictive analytics is also one of its important applications. Through the utilization of machine learning algorithms and predictive models, enterprises can acquire valuable insights pertaining to forthcoming trends and patterns. Data visualization has the potential to enhance collaboration and communication among entities. The implementation of visual aids to represent intricate data sets can facilitate fast comprehension and analysis of information by personnel within organizations. The adoption of this approach has the potential to enhance the efficacy of decision-making procedures and foster interdepartmental cooperation (Knaflic, 2015). Data visualization helps to enhance decision-making processes and detect trends and patterns that can facilitate operational efficiency for companies in all the fields where it is applied. This paper aims to examine prevalent applications of data visualization and its potential to enhance business outcomes using several industries as examples.

Data visualization is employed in the field of finance for risk management, financial analysis, and investment choices. Its tools, for instance, can assist in identifying trends in financial data, such as stock prices, that may not be immediately obvious in conventional formats. The detection of criminal activity in the finance sector has also been made easier by data visualization. Financial organizations have been qualified to monitor and track transactions with the aid of data visualization tools, allowing them to spot irregularities and take the necessary action. Additionally, by giving decision-makers a thorough understanding of the risks related to different financial instruments, data visualization has been used in risk management to enhance decision-making. Risk managers now find it simpler to recognize possible hazards and to take action to minimize them largely due to the usage of visual representations (Clark, 2020).

In healthcare data visualization is utilized for observing the patients, their

illnesses and making decisions in clinical settings. It can be used to spot patterns in patient data like blood pressure and heart rate that may need medical care. Data visualization's use in the healthcare sector has significantly improved the treatment of patients, cut costs, and increased the effectiveness of healthcare services. Using visualizations like graphs, charts, and maps, healthcare specialists can now evaluate and understand vast quantities of data, including information about patients, medical research, and clinical studies, making it easier to spot trends and patterns that can be used to enhance healthcare services. The capacity to improve patient outcomes is one of data visualization's most important contributions to the healthcare sector. Healthcare workers can examine patient data using data visualization tools and spot trends that can be utilized to tailor treatment strategies and improve patient outcomes. Additionally, by tracking outbreaks and observing disease progression, data visualization has made it easier to identify public health issues. Healthcare personnel can detect regions with high occurrence rates using visual representations like maps, allowing them to deploy resources and take the necessary precautions to stop the spread of diseases. The use of data visualization in healthcare has also reduced costs and increased operational effectiveness. The monitoring and tracking of expenditures by healthcare organizations using data visualization technologies helps them spot inefficiencies and areas of waste. Healthcare personnel now have an easier time spotting potential for cost-savings due to the usage of visual representations, which has led to large cost savings. The benefits of using data visualization in the healthcare sector are supported by vast amount of statistical evidence.

In marketing, data visualization is employed for social media tracking, optimization of campaigns, and customer segmentation. For instance, data visualization can assist in identifying trends in consumer behavior in order to guide marketing strategies, such as past purchases and website interaction. Data visualization has developed into a crucial tool for the marketing sector, enabling marketers to better understand consumer behavior, assess the success of marketing campaigns, and make more informed decisions. Marketers can now analyze large

amounts of complicated data quickly and efficiently and explain their findings by using visual tools like graphs, charts, and dashboards. Enhanced campaign efficiency is one of the important results of using data visualization in marketing. Marketers may assess the success of their campaigns in real-time, pinpoint areas for improvement, and make data-driven decisions by using visualizations. Additionally, data visualization has made it easier to identify customer behavior trends, allowing marketers to target their advertising more specifically. It is now simpler for marketers to gain insight into consumer tastes and adjust their marketing strategies as a result of the utilization of graphical representations of customer data, such as purchase history, web activity, and social media behavior. Additionally, data visualization has helped marketers make better decisions by giving them access to current market trends and consumer preferences. Dashboards allow marketers to track market trends in real-time, spot new trends, and take rational decisions.

Data visualization is utilized in education to build curricula, assess progress of learners, and allocate resources. In order help guide curricular adjustments, data visualization, for instance, might assist in identifying topics where students are having difficulty, such as specific subjects or tasks. The usage of data visualization in the education sector has resulted in improved student engagement, improved decision-making for teachers, and improved learning outcomes. Teachers can now effectively convey complicated information and data to students because of the use of visuals like graphs, charts, and infographics, which has boosted student achievements and results. A major benefit of using data visualization in education is enhanced student learning outcomes. Using visual aids, teachers can explain difficult ideas and facts in a manner that students can easily comprehend. This ultimately results in better student performance and outcomes. Additionally, data visualization has made it easier to identify trends in student performance, enabling teachers to tailor their teaching strategies. It has been simpler for educators to assess student learning needs and adapt their teaching strategies as a result of the usage of graphic representations of student data, such as test scores, attendance, and conduct. Moreover, data visualization has helped educators make better decisions by giving

them access to current information about the needs and performance of their students. Dashboards allow teachers to keep an eye on students' progress in real time, pinpoint areas that need work, and come to wise conclusions.

The use of data visualization in the renewable energy sector has produced a number of important advantages, including enhanced decision-making for energy suppliers and increased efficiency and cost savings. Energy providers have been able to track and maximize energy output with the help of visual tools like graphs, charts, and infographics, which has enhanced efficiency and reduced costs. Additionally, data visualization has made it easier to spot patterns and trends in energy consumption, which has helped energy providers make better decisions and create more successful energy strategies. Efficiency improvement is one of the most important effects of data visualization in the renewable energy sector. Energy suppliers may monitor energy output and consumption in real-time with the help of visualizations, allowing them to instantly spot and rectify inefficiencies (https://blog.virtualitics.com/how-data-visualization-is-redefining-the-energy-sector, 2021). Additionally, the ability to spot patterns and trends in energy consumption has helped energy providers to create more efficient plans. Suppliers can track energy use across several regions and pinpoint areas for improvement with the help of dashboards and other visual tools. As a result, they may create plans that are more effective and spend less money on energy. Data visualization has also made it easier to spot potential concerns with energy production and consumption, allowing energy companies to take preventative action to avoid disruptions and other problems. Energy suppliers can track energy production and consumption and see possible concerns before they become serious ones by using real-time data visualization technologies (https://site.check-it.ca/2021/08/benefits-of-data-visualization-in-energy-management/, 2021).

Managers working in environmental industry need visualization since they must base their decisions on extremely complicated data. Usage of visualization in practical environmental studies became more popular recently. It is preferable to have a variety of applications available for presenting findings (Sadiku and others,

2016). The use of data visualization in environmental science has made it possible for researchers to examine intricate environmental data and present their findings to a larger audience. Data visualization has made it possible for environmental scientists to explain their research results to decision-makers and the general public, enhancing environmental sustainability and fostering informed decision-making. The discovery of trends and patterns in environmental data is one of the most important effects of using data visualization in environmental science. Environmental scientists can examine big datasets and spot trends and patterns that might not be immediately obvious with the help of visual tools. Additionally, data visualization has made it possible for environmental scientists to share their findings with the public and policymakers, fostering informed judgment and supporting environmental sustainability. Scientists can convey complicated environmental data in a simple and succinct manner by using infographics and other visual tools. As a result, the general people and governments have more information to decide how to preserve the environment. Moreover, data visualization has made it easier for scientists to spot potential environmental issues and take preventative action to lessen or eliminate their effects. Environmental scientists can track environmental data and see possible issues before they become serious ones by using real-time data visualization technologies.

The utilization of data visualization in the decision-making process of libraries has contributed to the identification of significant trends and patterns in library usage and collection management. This has enabled librarians to effectively communicate their findings to stakeholders, identify potential collection management issues, and track and assess the impact of library services on customer satisfaction and academic success. The aforementioned results have facilitated the optimization of resource allocation in libraries, the creation of more efficacious library services, and the improvement of the overall user experience. By utilizing visual tools, librarians have the ability to scrutinize usage data and detect patterns in borrowing behaviors, resource utilization, and customer characteristics. The ability to customize services to cater to particular user groups and optimize resource allocation is facilitated by

this. In addition, the utilization of data visualization has empowered librarians to effectively convey their findings to interested parties, encouraging well-informed decision-making and streamlining library services that are tailored to meet the demands of users. Librarians can effectively convey difficult usage data through the utilization of infographics and other visual aids, which facilitate clear and succinct communication. This process facilitates the ability of stakeholders, including those in positions of authority within academic institutions, to make judicious determinations with respect to the allotment of library resources and the provision of related services. Moreover, the utilization of data visualization has aided in the detection of plausible collection management concerns, empowering librarians to adopt preemptive measures to enhance collection management. By utilizing data visualization tools, librarians can effectively track the usage of their collections and detect possible concerns, such as underutilized resources or gaps in the collection. This capability empowers librarians to make well-informed judgments with respect to the allocation of resources, development of collections, and removal of materials. Furthermore, the utilization of data visualization has assisted librarians in monitoring and assessing the influence of library services on user contentment and scholarly accomplishment. By employing surveys and other feedback mechanisms, librarians have the ability to gather data pertaining to user satisfaction and academic achievement. Through the utilization of data visualization tools, librarians can conduct an analysis of the data to identify potential areas for enhancement and assess the success of library services.

Although data visualization offers numerous benefits for data analysis and decision-making, it is essential to address its challenges as well. Organizations may use the power of data visualization to get insightful knowledge and boost operational performance by recognizing these challenges and putting the right solutions in place. This paper discusses some of the key data visualization challenges, including data quality, visual perception, data complexity, data security, and data interpretation and provide potential solutions to overcome these challenges. Ensuring data quality is one of the biggest issues in data visualization. Data quality refers to the accuracy,

completeness, consistency, and timeliness of data. Making sure the data is precise and trustworthy is one of the primary problems of data visualization. Inadequate or inaccurate data can result in drawing the wrong conclusions and making the wrong decisions (Keim, 2010). It is crucial to have a full awareness of the data sources and their reliability in order to overcome this difficulty. Techniques for cleaning data, like locating and eliminating outliers, can serve to enhance the quality of the data. Visual perception is another significant obstacle in data visualization. It can be difficult to build visualizations that effectively convey findings to everyone since different people process visual information in various ways. Color, size, and shape are just a few examples of how people's perceptions of visualizations might vary. The creation of successful designs that precisely and efficiently explain the data can be challenging at times. According to Few (2012), the design must be user-friendly, eye-catching, and applicable to the target audience. Understanding the rules of visual perception and creating visualizations that adhere to them are crucial for overcoming this issue. Correct understanding of data visualization can be achieved by utilizing the right colors and sizes, reducing difficult data, and providing clear labels and titles. Data complexity is also a challenge in data visualization. Finding patterns and trends in data can be difficult due to its complexity and growing number. It is essential to select visualization methods that can successfully portray complex data. For instance, heatmaps can be used to show patterns in huge datasets, while scatter plots can be used to show connections between two variables. One more hurdle for firms using data visualization technologies is security of data. If the data is not well protected, it may be subject to robbery or misconduct, which might have major ramifications for the company (McNurlin & Sprague, 2017). The final issue in data visualization is data interpretation. If the viewer fails to understand the context or underlying data, even the best-designed visualizations can be misunderstood. For viewers to effectively interpret visualizations, it is imperative to give sufficient context and background information. The constraints and uncertainties related to the data and analysis must also be communicated.

Some of the other challenges in data visualization include tools and technology

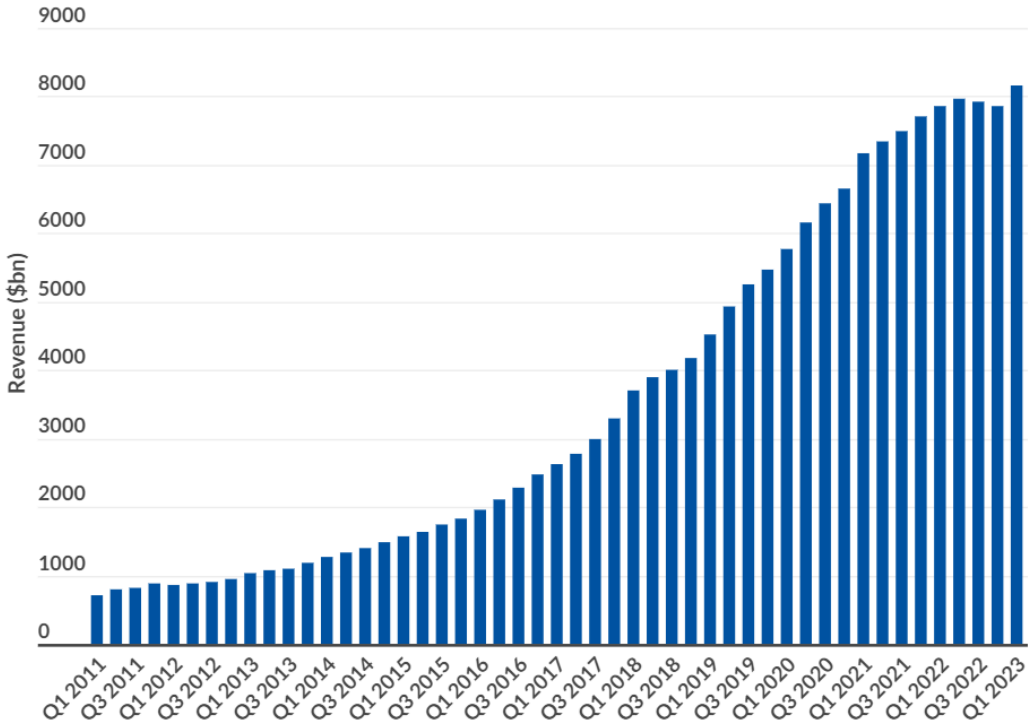
used while visualizing the data, dataset size, plotting style and overall cost of the software. It can be difficult to pick the right technologies and instruments for data visualization. Businesses must select the best tool for their unique needs from a wide variety of tools that are accessible, each with unique strengths and drawbacks (Heer and others, 2012). Because datasets quickly grow in size, it can be difficult to design visually appealing charts that effectively depict the data while being simple to understand. Significant computational resources may be needed to examine and evaluate large datasets. In order to overcome these difficulties, methods like data aggregation, sampling, and filtering can be employed to condense the dataset and emphasize the most crucial data (Kirk, 2016). The successful presentation of a visualization can also be impacted by the plotting style selection. Different types of data call for different types of visualizations, and choosing the incorrect type of plot can produce results that are inaccurate or unclear. When choosing a visualization type, it's crucial to keep the visualization's goal, data type, and audience in mind (Few, 2012). It might be difficult to afford data visualization tools, especially for individuals or small businesses with tight budgets. Although there are many open-source and free tools for data visualization, some of the more sophisticated technologies can be quite costly. When choosing a data visualization tool, it's critical to take the cost of the software into account and to make sure the tool offers the functionality and capabilities required for the planned use case (Steele, 2010).

CHAPTER III. THE IMPORTANCE OF DATA VISUALIZATION AND ITS DEVELOPMENT PROSPECTS

3.1. The role of BI and data visualization tools in business success of Netflix and Procter & Gamble

Many well-known companies have successfully implemented BI and data visualization techniques and were able to improve their business performance. Netflix and Procter & Gamble are two examples of such companies. For example, Netflix, an American media company, has managed to gain 220.6 million subscribers worldwide by 2022. The company was launched in 1997 and was providing DVD-rental services at that time before it turned into a streaming service. However, Netflix was already focused on provision of customized experiences and recommendations before it launched its streaming service. The company was so successful in what it was doing that it won "Emmy Engineering Award" which is

Figure 14. "Netflix Quarterly Revenue 2011 to 2022 ($mm)"

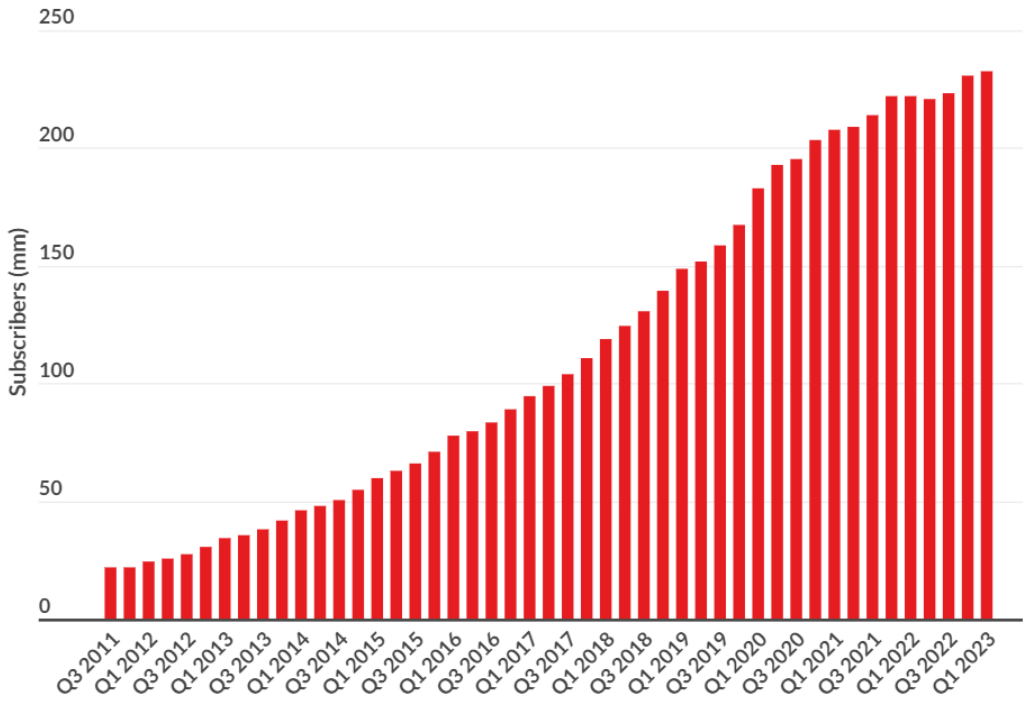


Source: Mansoor Iqbal, "Netflix Revenue and Usage Statistics", https://www.businessofapps.com/data/netflix-statistics/, 2023

usually awarded to people or companies that have significantly altered the way

people watch television. Netflix's success inspired other organizations, like Amazon Prime, Hulu, and Disney Plus to launch streaming service and copy its formula. Figure 14 displays the company's quarterly revenue over 12 years, from 2011 to 2022. In 2022, Netflix made $31.6 billion in revenue, a 6.7% increase compared to the previous year. North America, the company's biggest market, accounted for $14 billion of that total. In quarter 1 of 2023, the company generated $8.162 billion. Figure 15 illustrates the number of subscribers that Netflix had during the same period, from 2011 to 2022. Its subscriber count had its first fall in Q1 2022, but since Q3 2022, it has experienced two quarters of rise (Iqbal, 2023). The market capitalization of Netflix as of May 2023 is $143.48 billion which places Netflix in the position of 85th most valuable firm in the world. Since the company went public, it had the highest market worth in 2021 when its value was $267.46 billion (https://companiesmarketcap.com/netflix/marketcap/, 2023).

Figure 15. "Netflix Subscribers - 2011 to 2022 ($mm)"

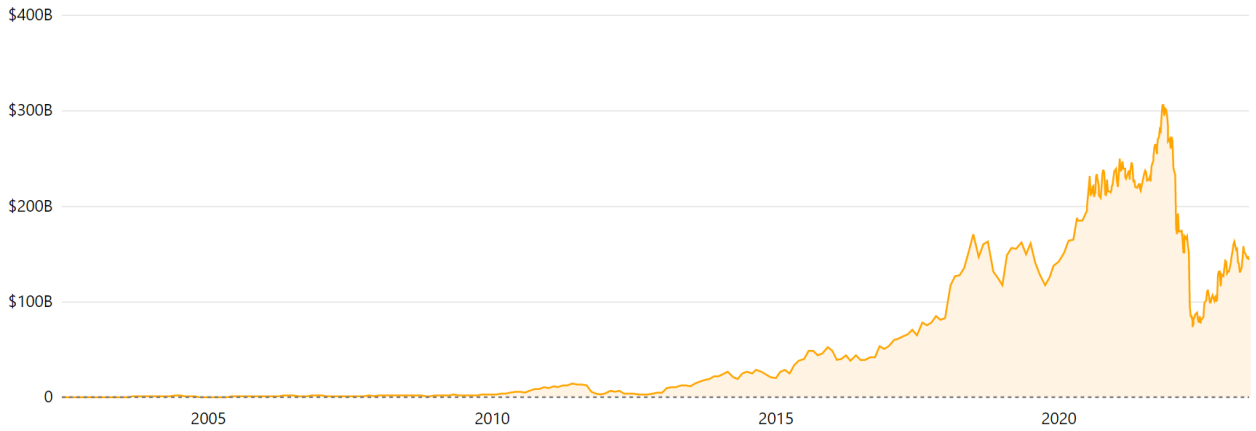


Source: Mansoor Iqbal, "Netflix Revenue and Usage Statistics", https://www.businessofapps.com/data/netflix-statistics/, 2023

The main reason for the decline in its value was increased competition due to launch of new platforms providing streaming services. Figure 16 describes Netflix's market

value from 2022 to 2023. The company's success can be attributable to its remarkable 93% subscriber retention rate, which is higher than Hulu's 64% and Amazon Prime's 75% (Iqbal, 2023). But they have been successful in more ways than just keeping the majority of its 151 million members. Netflix has surpassed its rivals because it also has a large and diverse content library. Netflix has a sizable and varied content catalog, with a wide range of TV series, films, documentaries, and original works available in numerous languages and genres. A wide spectrum of

Figure 16. Netflix's Market Value from 2022 to 2023



Source: "Market Capitalization of Netflix", https://companiesmarketcap.com/netflix/marketcap/, 2023

viewers find this diverse content catalog appealing, which helps Netflix draw in and keep users. Another secret to Netflix's success is its ability to gather and use data. Netflix uses advanced algorithms to assess user viewing patterns and recommend new material that users are likely to like. Users are interested and motivated to keep watching because of the company's personalized suggestion system. Netflix's success serves as a prime example of the usefulness of data analytics since it offers a remarkable understanding of user preferences and enables users to make informed decisions that maximize return on investment. Netflix uses data analytics to learn about customer behavior and purchasing trends by gathering information from their 151 million customers and applying data analytics models. Using that knowledge, they would then suggest movies and TV series depending on the tastes of their members. In order to build a comprehensive picture of its members, Netflix gathers

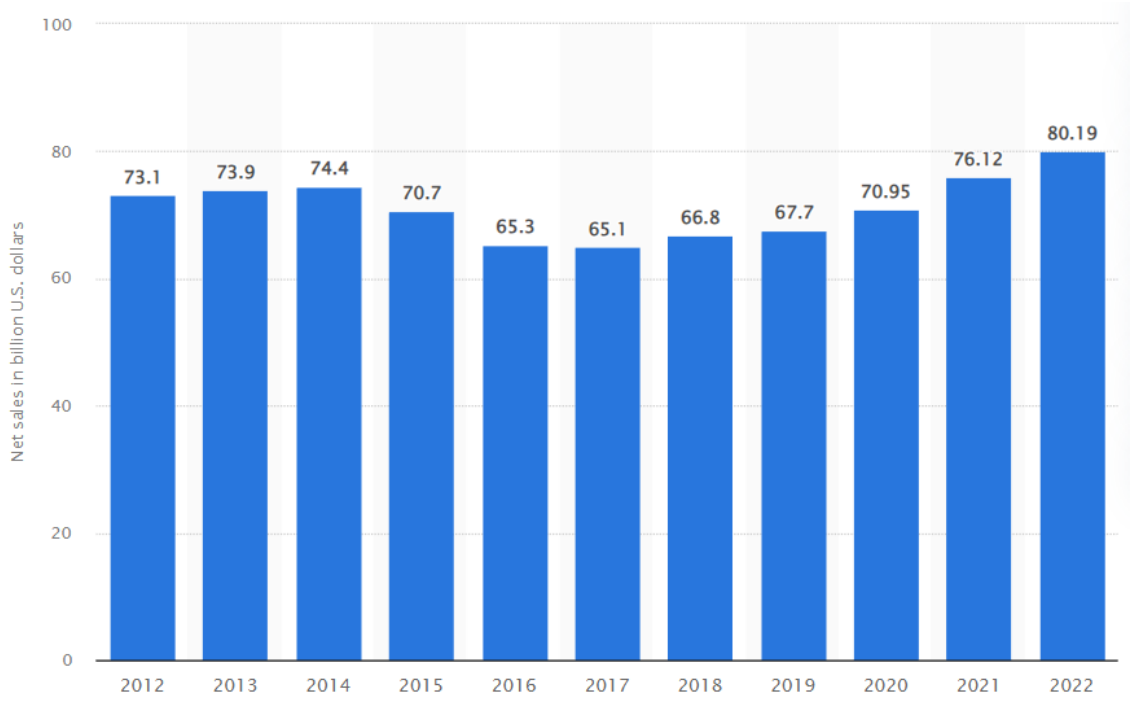
a variety of data elements. Compared to personas developed by traditional marketing, the users' profile on Netflix is significantly more complete. The company knows which scenes its customers watched several times, whether they liked that scene and rated it, how many searches they made and what exactly they searched for. With this information, Netflix creates a detailed user profile. The company utilizes data analytics to gather all of this data and turn it into useful knowledge. It employs data visualization to view the data and make better decisions. Netflix claims that because the recommendation system accounts for more than 80% of the material streamed on the network, they earn over a billion in user retention. Most importantly, Netflix is accessible on a variety of platforms, including smart TVs, smartphones, tablets, and gaming consoles. Users can access information on any device, at any time, from anywhere.

Moreover, Netflix is recognized for its cutting-edge business tactics, which include putting a significant amount of money into original content, embracing the binge-watching trend, and releasing full seasons of series at once. These tactics have helped Netflix stand out from rivals and build a devoted customer base. Netflix is available in more than 190 countries, and it has tailored its marketing and programming to appeal to regional consumers. Because of its global presence, Netflix has been able to increase both its consumer base and revenue sources. Finally, Netflix welcomes customer input. One feedback mechanism is the thumbs-up/thumbs-down system, which took the place of their rating system and significantly increased audience involvement. This improvement allowed them to further customize the user's homepage (Dixon, 2019). Netflix knows what type of shows to create, in which countries or regions to introduce those shows to gain maximum market share. On top of that, Netflix uses data visualization to track the performance of its marketing campaigns, including click-through rates, engagement rates, and conversion rates. This allows the company to optimize its marketing strategies and reach the right audiences with the right message. Furthermore, Netflix uses data visualization to track its operational performance, including server performance, streaming quality, and user complaints. This helps the company to

identify and resolve issues quickly, reducing downtime and improving the user experience.

Another company example that successfully implemented data analytics including data visualization is an American company - Procter & Gamble or P&G. It is headquartered in Cincinnati, Ohio and founded in 1837 by William Procter and James Gamble. The company has operations in over 180 countries. According to

Figure 17. "Procter & Gamble's Net Sales Worldwide from 2012 to 2022 ($bn)"

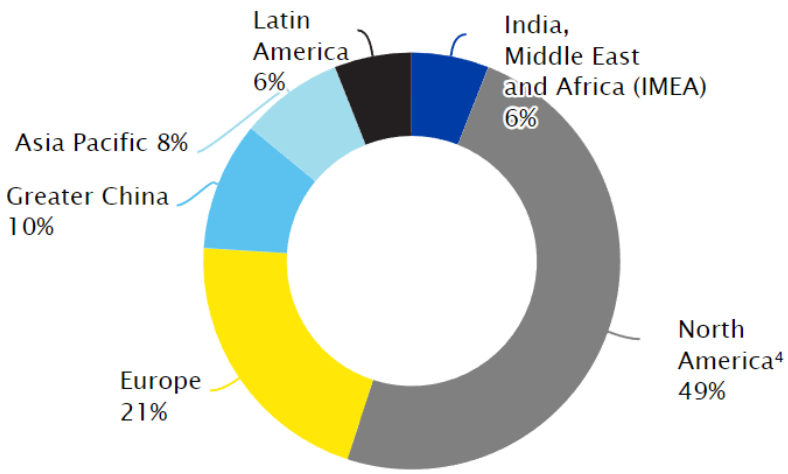


Source: Statista, https://www.statista.com/statistics/238751/net-sales-of-procter-und-gamble-p-und-g-since-2005/, 2022

Figure 17, its global sales have reached $80.19 billion in 2022 (https://www.statista.com/statistics/238751/net-sales-of-procter-und-gamble-p-und-g-since-2005/, 2022). Figure 18 illustrates P&G's global sales by geographical region. As can be seen, its largest market is North American region where it sells 49% of its products. In order to keep its position as the world market leader, P&G continuously analyzes market developments, acts swiftly when necessary, and looks for new opportunities to enhance the quality of life for its customers. To operate a real-time business, one must be able to interpret this vast volume of data and be flexible to market changes. P&G is capable of maintaining its worldwide status due to its smart employment of data visualization techniques and data analytics in

general. Data visualization has been established as a main tool of managment by P&G. P&G uses visualization tools such as Tableau to create interactive dashboards that provide real-time insights into its business performance. These dashboards enable P&G's decision-makers to quickly identify issues and opportunities, and take

Figure 18. P&G Sales by Geographical Region for 2022

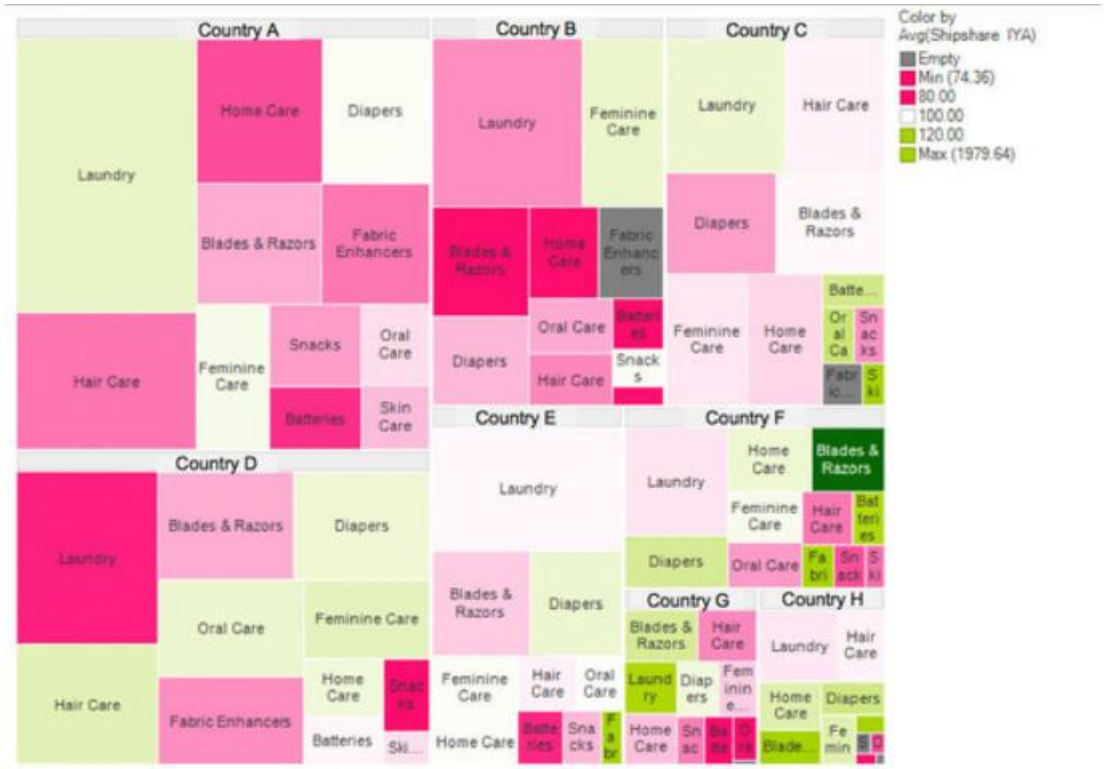


Source: “P&G at a Glance”, https://www.pginvestor.com/about-p-g/p-g-at-a-glance/default.aspx, 2022

appropriate actions. The company has also given an access to more than 50,000 employees to a “Decision Cockpit” created with the help of visual analytics software vendor Tibco Spotfire. “Decision Cockpit” is a dashboard that displays easy-to-read charts illustrating business status and trends. In addition to that, in over 50 areas, P&G has constructed meeting places it refers to as "Business Spheres" where managerial data is presented for evaluation and decision-making by teams. Although the majority of these spaces are traditional rectangular meeting rooms that have recently been furnished with huge screens on the walls, some of them are genuinely spherical in shape. P&G management meets in these rooms all around the world, analizes the company's data and makes informed decisions. Moreover, Microsoft Teams and other collaboration platforms are used by P&G to allow its staff to share information. This promotes an organizational culture of data-driven decision-making. On top of having a standard style of presenting information, the business has created numerous models that outline the information that should be used to

solve certain problems. P&G also actively uses heat maps to indicate how its products are performing in their different markets, but they are not meant to impress managers with their originality and coolness. The main objective is to make it easier for them to rapidly grasp what is happening in the company and figure out what to do about it. The heat map displayed in Figure19 is a standard one for P&G Europe and it simultaneously displays all the markets where P&G operates and their relative market share as well as the significance of increasing the share of any one of those markets. Here, colors denote market shares with red denoting low and green denoting high market share. With the help of such visual analytics, P&G can swiftly draw the attention of corporate decision-makers to the most important challenges

Figure 19. P&G's Heat Map



Source: Thomas H. Davenport, "How P&G Presents Data to Decision-Makers", https://hbr.org/2013/04/how-p-and-g-presents-data?goback=.gde_35222_member_229680414, 2013

facing the company. P&G makes sure that its data is consistent throughout the organization. It makes an effort to keep its visuals and color schemes straightforward so that managers, no matter where they are in the world, can concentrate on the crucial business challenges. The company also utilizes seven "business sufficiency

models" to define which data is used to solve certain problem domains. For instance, if you're interested in supply chain difficulties, the sufficiency models identify the important variables, how they should be visually demonstrated and the connections between the variables and predictions based on the correlations (Davenport, 2013).

P&G aspires to be the industry leader in terms of advanced technology. Their goal is to be permanently linked to all of their retailers and customers, in order to monitor any good at any time as it travels through a production line anywhere in the globe, and to be able to watch it at any time as it goes through the production process. It may be clear that doing so requires an enormous quantity of data, as well as complex algorithms and models. They employ simulation analytics, for instance, when creating new goods. Simulation analytics creates and modifies various models or designs virtually while accounting for a wide range of variables to assure the best possible product performance. In order to identify the optimal design for a disposable diaper or when designing a new dishwashing detergent, P&G utilizes simulation models and predictive analytics to quickly produce thousands of variants instead of creating new designs by hand (Rijmenam, 2014). To forecast demand, optimize inventory levels, and spot potential supply chain interruptions, P&G uses predictive analytics. The company may lower costs and increase the effectiveness of its supply chain by utilizing these solutions. As part of its commitment to continuous improvement, P&G periodically assesses the effectiveness of its BI and data visualization tools to make sure they are fulfilling the demands of its operations. By using this strategy, P&G can stay flexible and quick to adjust to shifting market circumstances.

The examples of these two companies described above serve as a proof of success of employing BI and data visualization technologies. Despite some drawbacks which were also discussed in this paper, benefits prevail. Unfortunately, not all the companies can afford this technology, but eventually, it will turn into a necessity if companies want to survive in ever increasing competition.

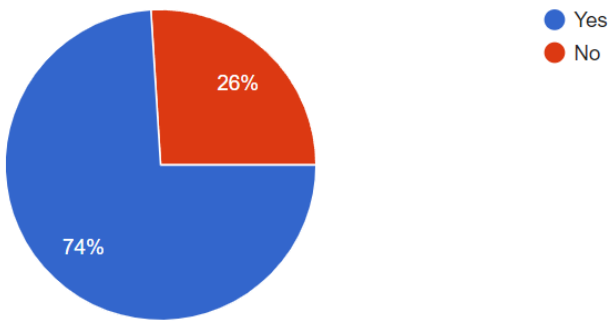
3.2. Suggestions on how to increase the business performance using modern data visualization techniques based on the survey conducted among the teachers of LANDAU School

In today's business operations, data visualization has become crucial. For making informed business decisions, the ability to display facts in a clear and simple manner is essential. Modern data visualization techniques can be used to increase business performance using various strategies for leveraging data visualization to drive business growth. Firms can avoid challenges they face while using data visualization technology by following some best practices. Unfortunately, not all the industries and not all the companies are aware of those practices and follow them. Developed countries usually get the most benefit from data visualization technology compared to developing countries. Therefore, firms located in developing countries often fall behind the technological development and may face a fierce competition if they decide to operate in several countries.

One of the fields where data visualization tools can significantly increase business performance is education. The benefits of BI and data visualization tools for education and some other fields were discussed in section 2.3 of this research paper. Due to the fact that firms in developing countries are more in need of suggestions on how to improve their performance through data visualization technology, the educational organization chosen for this research was LANDAU School located in Azerbaijan, Baku. An online survey among the sample of 50 teachers working at LANDAU School was conducted with the purpose of measuring the extent by which data visualization tools are employed in education sector of Azerbaijan. The reason for choosing the private school was that it has more motivation and finances to invest in data visualization tools as this helps to improve the quality and attract more customers, in this case – students. LANDAU School is Azerbaijani private school with 5 campuses located in different parts of Baku city. It offers extensive curriculum where students can choose to study national (local) or international (British) curriculum. Overall, it has 780 employees including teachers and 3,200 students in all campuses together. The school should utilize data

visualization tools extensively to ensure high quality of education. Secondary school teachers are expected to use data visualization tools more than primary school teachers because of the level of complexity that their subjects entail. Similarly, teachers teaching international curriculum are more likely to utilize data visualization tools than those teaching local curriculum because of the same reason and additionally, due to language barrier (most of the tools do not have azerbaijani language version). Secondary school at LANDAU has 5 departments which are Humanities, Modern Foreign Languages (MFL), Science, Math, and English. For this study purposes, the sample of 50 teachers teaching international curriculum in secondary school was chosen and surveyed. For equality purposes from each department only 10 teachers were surveyed. As a result, it was found that 74% of the teachers are employing data visualization tools in their work while 26% are not. Figure 20, displays the pie chart

Figure 20. The Proportion of LANDAU Teachers that Use Data Visualization Tools

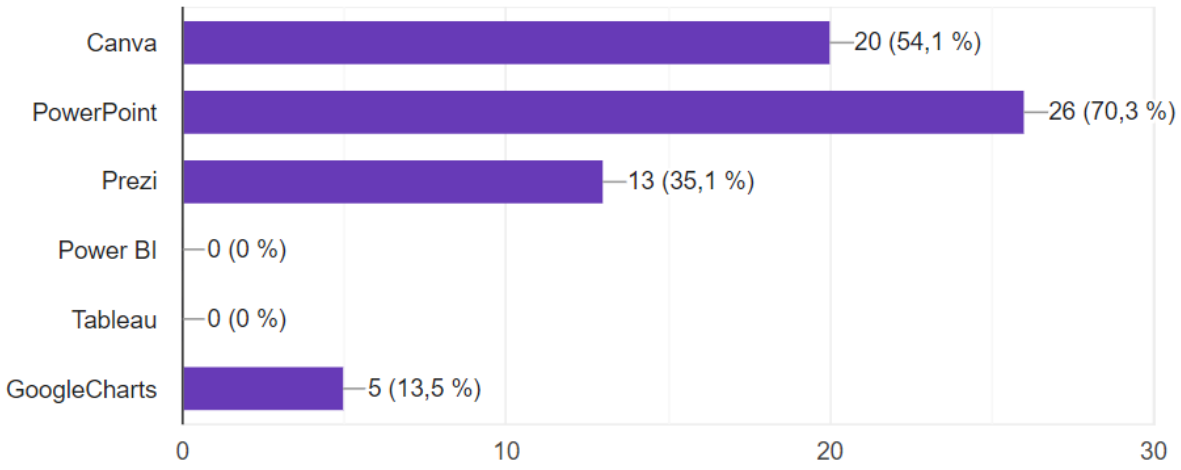


Source: The Author's Calculations

generated using the survey data. It was also found that the teachers are employing different tools, such as Canva, PowerPoint, Prezi, and GoogleCharts. Figure 21 illustrates the popularity of each of these tools. As can be observed from the data, the most popular tools employed are PowerPoint (70,3%) and Canva (54,1%). 35,1% of surveyed teachers are also using Prezi. GoogleCharts, PowerBI, and Tableau are the least popular visualization tools. The main reasons behind such trend are assumed to be the cost of these visualization tools and the familiarity of the staff

with them. Once Microsoft Office programs are installed, PowerPoint is free of charge, while other programs require a subscription fee. On top of this, LANDAU offers laptops with already installed Microsoft Office programs to all of its employees which makes this visualization tool more accessible to the staff. Teachers

Figure 21. Data Visualization Tools Used by LANDAU Teachers



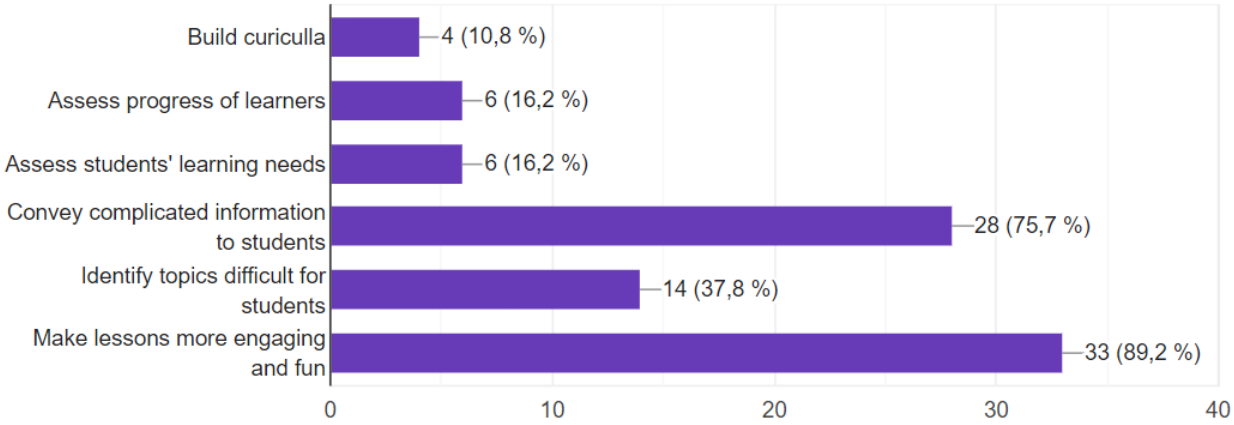
Source: The Author's Calculations

also use Canva most probably because it has a lot of features that are free of charge. Unfortunately, although such programs like Power BI, Tableau and Google Charts are very helpful in creating valuable data visualizations, they are not popular among teachers not only because of their cost (Google Charts is free of charge), but also due to the fact that teachers are not informed about their existence and do not know how to utilize them.

Another important conclusion that was drawn from the survey is related to the purpose of using data visualization tools. According to Figure 22, 89,2% of respondents answered that they use data visualization tools to make lessons more engaging and fun and 75,7% responded that they try to convey complicated information to students in more understandable way. Moreover, 37,8% of surveyed teachers responded that they use data visualization tools to identify topics difficult for students. Despite the fact that these objectives for using the technology are important for ensuring the quality of education at school, the survey results show that teachers are not utilizing the benefits of data visualization tools to the full extent.

Some of the additional benefits they could get from those tools are building curriculum, assessing the progress of learners, and assessing students' learning needs which is very important if the school wants to improve the quality of services it provides. The list can be continued further, but these are the most important benefits. The main reason behind not fully benefitting from the visualization tools

Figure 22. Purpose of Using Data Visualization Tools at LANDAU



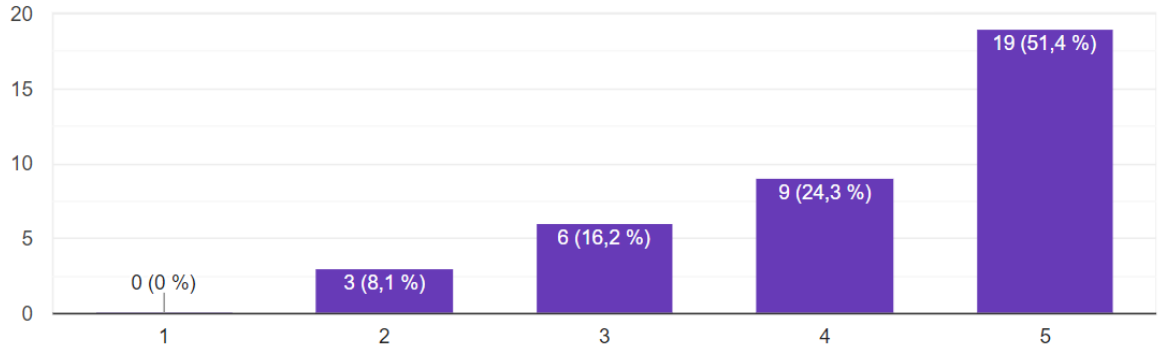
Source: The Author's Calculations

is assumed to be the fact that teachers are not using more advanced data visualization tools, which was already displayed in Figure 21 and they are not aware of the benefits they could enjoy if they correctly use the technology they have in their hands. Moreover, they do not have enough expertise in using those visualization tools.

Nevertheless, the respondents realized the value of data visualization tools for improving the quality of their work and the quality of education in the whole school. Figures 23 and 24 graphically demonstrate the extent to which they realize these facts. On a scale from 1 to 5, more than 50% of respondents rated the importance of data visualization for their work as being highly valuable and chose 5. Similarly, even more teachers realized the importance of data visualization tools for the quality of school as a whole. 62,2% of respondents rated the importance as being highly valuable and chose 5. When asked whether LANDAU School gets the most benefit from data visualization, 60,5% of the surveyed teachers responded that it does not. Figure 25 illustrates this data on a pie chart.

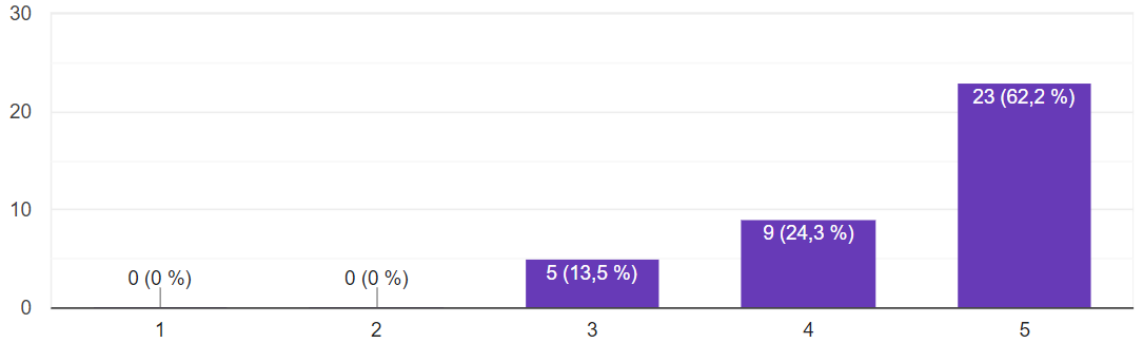
To sum up the results that were obtained from the survey, LANDAU School does not fully utilize data visualization technology that is available nowadays and should be used in education sector to ensure high quality of the services provided.

Figure 23. The Value of Data Visualization Tools for Improving the Teachers' Work



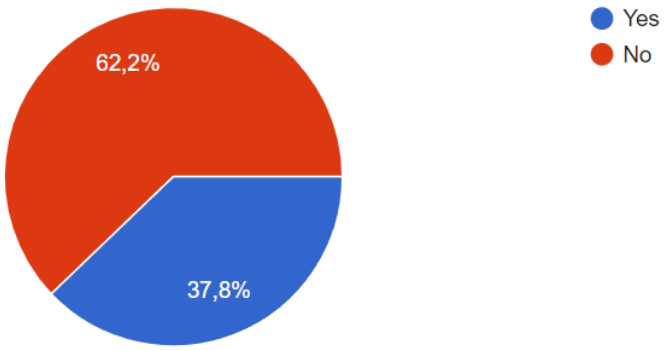
Source: The Author's Calculations

Figure 24. The Value of Data Visualization Tools for Improving the Quality of Education at LANDAU



Source: The Author's Calculations

Figure 25. The Degree to which LANDAU School Gets the Most Benefit from Data Visualization



Source: The Author's Calculations

The teachers are not aware of the existence of some of the tools that could fasten

and alleviate their work and they are also not trained to use the technology that is in their hand. This was proven by the fact that teachers could get more benefit than they think by correctly using at least the technology that they have. The last question of the survey was asking about the suggestions that teachers could provide to LANDAU School in order to increase the benefit that the school currently gets from data visualization tools. Some of the suggestions included promotion of data visualization tools through provision of trainings to the staff on how to use those tools and investment of funds into more advanced data visualization tools.

Using the example of LANDAU School, some of the general suggestions to other companies on how to fully utilize data visualization tools and get the most from them can be provided. If companies want to employ data visualization techniques to the full extent, they need to fist clearly define their goals and objectives and understand how it will assist them in making decisions (Berinato, 2016). Additionally, companies should keep their visualizations simple and easy to understand because the primary goal of data visualization is to communicate insights in a clear and concise manner (Hammond, 2023). Furthermore, firms should train employees on how to use data visualization tools effectively. This includes teaching them how to interpret visualizations, how to create effective visualizations, and how to present the findings to stakeholders.

It is also crucial to fully understand the data before any visualization can be produced. In order to do this, the data must be examined for trends, patterns, and correlations. After the data has been examined, the best visualization method can be chosen. For instance, a time-series graphic would be suitable if the data was temporal. Likewise, a map-based visualization can be produced if the data contains geographical information. Organizations can find opportunities for expansion and take reasoned decisions by analyzing the facts. One of the most critical aspects of data visualization is data quality which was described above as a goal that is challenging to achieve. Incorrect judgments and bad decisions might result from poor data. Organizations should engage in data cleaning and validation processes to ensure data quality. This includes finding errors and fixing them, getting rid of

duplicates, and making sure that the data is consistent across all sources. Organizations may improve the accuracy of their visualizations and make wise judgments by guaranteeing data quality. If the businesses want to become successful in implementing data visualization tools, they should also choose the right visualization technique. There are many different visualization methods available, so it's important to pick the one that's best for the data being examined. Bar graphs, line graphs, scatterplots, and heat maps are a few examples of common visualization approaches. Organizations can show data in a way that is simple to grasp and interpret by selecting the right visualization strategy. This makes it easier to notice trends and patterns that might be challenging to find using other techniques.

Utilization of interactive visualizations that allows users to explore data in real-time, enabling them to identify trends and patterns that may not be apparent using static visualizations is another strategy which firms can use. Interactive visualizations can be used to drill down into specific areas of data and compare different data sets. By providing users with the ability to interact with data, organizations can encourage exploration and increase engagement (Kirk, 2016). In addition, data patterns and trends that might not be obvious using conventional approaches can be found using machine learning techniques. Outliers can be found, future trends can be predicted, and correlations between variables may be discovered using machine learning algorithms. Businesses may get a deeper understanding of their data and make better decisions by integrating machine learning techniques into data visualization.

Businesses are additionally advised to build a data-driven culture, invest in modern data visualization tools, align data visualization with business goals, and communicate insights effectively in order to successfully utilize modern data visualization tools. Organizations need to create a data-driven culture that appreciates data and promotes data-driven decision making in order to fully reap the benefits of data visualization. This entails making sure that workers have access to the tools and data they require, as well as providing them with the training and assistance they need to use the data efficiently (Kumar, 2018). Companies must

invest in cutting-edge data visualization tools that are user-friendly, adaptable, and capable of handling massive amounts of data if they want to fully realize the potential of this technology. This can entail making investments in tools or cloud-based solutions that can connect to current data infrastructure (Steel, 2010). For data visualization to be useful to the organization, it must be in line with business goals and objectives. This includes determining the crucial indicators and KPIs for the company and utilizing data visualization to track and keep an eye on these metrics (Few, 2012). It is important to effectively explain to decision-makers the insights obtained by data visualization. This means applying visualization tools to create a narrative out of data, making it simpler to convey significant discoveries and insights (Cairo, 2012).

CONCLUSION AND RECOMMENDATIONS

As was discussed in the first chapter of this paper, business intelligence and data visualization both have rich history and are important for businesses in the modern world to maintain their competitive advantage. Over the past centuries people were trying to illustrate on paper the locations of various places or cities, planets and stars visualizing the data in the forms of maps, charts or diagrams without even knowing that they are creating a foundation for the modern data analysis. Despite the fact that most of the advancements in data visualization have taken place relatively recently, the roots of it date back to the 2nd century AD. The creation of the earliest geometric diagrams showing the positions stars and planets as well as creation of maps that helped in navigation and exploration, the birth of probability theory, the beginnings of demographic statistics, theories of measurement and estimation, development of isolines and contours and the establishment of thematic mapping of physical quantities, invention of bar and pie charts, histograms, line charts, line graphs and time-series plots as well as comprehensive atlases and graphical analysis of lines of magnetism and weather, establishment of first official state statistical offices, creation of 3D surface maps of population data, the use of divided circle diagrams on map, polar area charts, semi-logarithmic graphs, age pyramids and etc. – all laid the foundation of modern data visualization.

Business intelligence on the other hand is relatively younger field compared to data visualization. Recognition of gathering and evaluation of the data to increase efficiency has laid the foundation for contemporary business intelligence. Emergence of computers, creation of the first business intelligence systems and applications, like SAP and JD Edwards, development of database management systems, establishment of tools like ETL and OLAP that simplified the process of queries, generation of big data platforms like Hadoop and Spark and finally, emergence of the modern tools and methods, like artificial intelligence and machine learning has shaped business intelligence in the form we see today.

The second chapter of this research paper introduced such data visualization

methods like bar charts, pie charts, line charts, and scatter plots and described the purpose of usage of each method. Additionally, such data visualization tools and softwares as Python, R, QlickView, Tableau, PowerBI, and Google Charts were discussed. Some of these tools are free, while others have some cost. Generally, positive and negative sides of each of these tools were covered. The results companies want to get, the type of data they want to analize and their strategic plans were identified as the main factors influencing the choise of a particular type of method or tool. Finally, the last section of the second chapter introduced the importance of data visualization for businesses, its aplications to various fields and industries and challenges the firms may face while utilizing data visualization tools. The paper highlighted the benefits the firms in different fields may get from visualizations. For example, in the field of finance it is used for risk management, financial analysis, and investment choices. In healthcare data visualization is utilized for observing the patients, their illnesses and making decisions in clinical settings. In marketing, data visualization is employed for social media tracking, optimization of campaigns, and customer segmentation. Data visualization is utilized in education to build curricula, assess progress of learners, and allocate resources. Energy providers have been able to track and maximize energy output with the help of visual tools like graphs, charts, and infographics, which has enhanced efficiency and reduced costs. The use of data visualization in environmental science has made it possible for researchers to examine intricate environmental data and present their findings to a larger audience. The utilization of data visualization in the decision-making process of libraries has contributed to the identification of significant trends and patterns in library usage and collection management which has enabled librarians to effectively communicate their findings to stakeholders, identify potential collection management issues, and track and assess the impact of library services on customer satisfaction and academic success. Despite a lot of fields benefitting from BI and data visualization techniques, some of the key data visualization challenges facing firms were also highlighted. The challenges included data quality, visual perception, data complexity, data security, and data

interpretation. The paper provided potential solutions to overcome these challenges. Organizations may use the power of data visualization to get insightful knowledge and boost operational performance by recognizing these challenges and putting the right solutions in place.

The last chapter of this research paper describes two bright examples of companies which successfully utilized various BI and data visualization techniques and became market leaders in the fields they operate. Those companies are Netflix and Procter & Gamble. They both managed to increase their sales, reduce their costs, increase revenues and achieve customer satisfaction. They serve as examples for other companies and encourage the firms which are not familiar with BI and data visualization tools to invest in them. Finally, the research paper concludes with the analysis of the value of data visualization tools to one of the Azerbaijani private schools – LANDAU School by evaluating the results of the online survey conducted among 50 teachers employed at LANDAU. The result of the survey showed that the teachers at the school are not familiar with all the benefits they could get from utilizing the data visualization tools they have in their hands. Moreover, the school does not invest into more advanced visualization tools which could significantly increase the quality of the education services school provides. Based on the results found, some recommendations on following certain strategies that will allow companies to maximize the benefits they get from BI and data visualization tools at the same time avoiding some of the challenges were provided. These recomendations are useful for not only LANDAU School, but also to all other firms facing the same problem. The strategies that were recommended were as follows:

- clearly identify company's goals and objectives
- understand the data
- choose the right visualization technique
- invest in cutting-edge data visualization tools that are user-friendly, adaptable, and capable of handling massive amounts of data
- utilize interactive visualizations that allows users to explore data in real-time enabling them to identify trends and patterns

- build a data-driven culture
- invest in modern data visualization tools
- align data visualization with business goals
- communicate insights effectively in order to successfully utilize modern data visualization tools

Some of the recommendations for future research may involve exploring the role of machine learning and artificial intelligence in data visualization technology. This can entail investigation of how machine learning algorithms can be used to create more complex and insightful data visualizations, or how AI can be used to automate data visualization tasks. Moreover, the potential of augmented and virtual reality (AR and VR) in data visualization technology can also be investigated. This can involve exploring how AR and VR may be used to provide dynamic, realistic data visualizations that give users a better experience.

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APPENDIX

The sample of 50 teachers from LANDAU School was chosen for the online survey. The survey was confidential and was created using Google Forms and the questions the teachers responded were as following:

1. What department do you work in?

- Humanities
- Math
- Science
- English
- MFL

2. What subject do you teach

- Math
- History
- Geography
- Economics
- Physics
- Chemistry
- Biology
- English

3. Do you use data visualization tools (like PowerPoint, Canva, Prezi, etc.) in your work?

- Yes
- No

4. What visualization tools do you use?

- Canva
- PowerPoint
- Prezi
- Power BI
- Tableau
- Google Charts

- Other – Please specify _____

5. What do you use visualization for?

- Built curricula
- Assess progress of learners
- Assess students' learning needs
- Convey complicated information to students
- Identify topics difficult for students
- Make lessons more engaging and fun

6. On a scale from 1 to 5, how would you rate the value of data visualization tools for improving the quality of your work?

1 – Very low value 5 – Very high Value

7. On a scale from 1 to 5, how would you rate the value of data visualization tools for improving the quality of education in the whole school?

1 – Very low value 5 – Very high Value

8. Do you think LANDAU School gets the most benefit from data visualization?

- Yes
- No

9. If you answered "no" to the previous question, please provide any suggestion on how to improve the situation.

_____

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