Czech University of Life Sciences Prague

Faculty of Economics and Management

Department of Information Engineering

Master's Thesis

An Analysis Over Extendibility of Data Analytics Tools for Custom Data Connector: Adobe Captivate Prime API Connector Development for Microsoft Power BI

Emre KARABULUT

CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Economics and Management

DIPLOMA THESIS ASSIGNMENT

B.Sc. Emre Karabulut

Systems Engineering and Informatics

Informatics

Thesis title

An Analysis Over Extendibility of Data Analytics Tools for Custom Data Connector: Adobe Captivate Prime API Connector Development for Microsoft Power BI

Objectives of thesis

The main objective of this thesis is to compare capabilities and extendibility of modern-day data analytic tools for integration based on the APIs, licensing, performance, and custom data connector development.

The partial goals of the thesis are to compare some aspects of tools, to create development environments and to develop a custom data connector for the selected tool and an external system.

Methodology

The theoretical part is based on the systematic literature review that provides an understanding of data and comprehensive benchmark of data analytics tools performed in aspect of both data analysts and data engineers with the help of public surveys, researches, websites, public market data and other written or online sources.

Followed by explaining data types, connector and their relations, the practical part will contain custom data connector development case study over Microsoft Power BI to create a connection between the third-party system via API as an external data source.

The proposed extent of the thesis

60-80 pages

Keywords

systems integration, business intelligence, data analytics, data connector, custom connector development, api, microsoft power bi

Recommended information sources

Erl, Thomas, Khattak, Wajid and Buhler, Paul. 2016. Big Data Fundamentals: Concepts. Drivers & Techniques. Crawfordsville : ServiceTech Press, 2016. 978-0-13-429107-9

Jin, Brenda, Sahni, Saurabh and Shevat, Amir. 2018. Designing Web APIs: Building APIs That Developers Love. s.l. : O"Reilly, 2018. 978-1-492-02692-1

Liu, Dahai. 2015. Systems Engineering Design Principles and Models. s.l. : CRC Press, 2015. 978-1-48-228246-7

Puls, Ken and Escobar, Miguel. 2015. M is for (DATA) MONKEY: The Excel Pro's Definitive Guide to Power Query. Florida : Holy Macro! Books, 2015. 978-1-61547-034-1

Rad, Reza. 2018. Pro Power BI Architecture: Sharing, Security, and Deployment Options for Microsoft Power BI Solutions. Auckland : APRESS, 2018. 978-1-4842-4014-4

Expected date of thesis defence

2021/22 SS – FEM

The Diploma Thesis Supervisor

Ing. Martin Pelikán, Ph.D.

Supervising department

Department of Information Engineering

Electronic approval: 24. 3. 2022

Ing. Martin Pelikán, Ph.D.

Head of department

Electronic approval: 28. 3. 2022

doc. Ing. Tomáš Šubrt, Ph.D.

Dean

Prague on 11. 04. 2022

Declaration

I declare that I have worked on my master's thesis titled "An Analysis Over Extendibility of Data Analytics Tools for Custom Data Connector: Adobe Captivate Prime API Connector Development for Microsoft Power BI" by myself and I have used only the sources mentioned at the end of the thesis. As the author of the master's thesis, I declare that the thesis does not break any copyrights.

In Prague on 11 April 2022 _____

Acknowledgement

This page was intentionally left blank
in memory of my dear grandfather Nazmi Özgür (1938-2021).

An Analysis Over Extendibility of Data Analytics Tools for Custom Data Connector: Adobe Captivate Prime API Connector Development for Microsoft Power BI

Abstract

Many modern software or systems build open APIs into their core, and this might be the way forward. The theme of this diploma thesis is comparing the capabilities and extendibility of modern-day data analytics tools (Google Data Studio, Qlik Sense, Microsoft Power BI, Tableau) for integration based on APIs, licensing, performance, and custom data connector development.

In the theoretical part of this thesis, a systematic literature review was conducted on the data domain, including systems integration, business intelligence, data analytics, data types, data sources, and data analytics tools.

In the practical part, a custom data connector was developed with M language in Microsoft Visual Studio with the help of Power Query SDK to create an integration between Microsoft Power BI and Adobe Captivate Learning Management System through Captivate Prime API as a case study.

Keywords: systems integration, business intelligence, data analytics, data connector, custom connector development, api, microsoft power bi

Analýza rozšiřitelnosti nástrojů pro analýzu dat pro vlastní datový konektor: Vývoj konektoru Adobe Captivate Prime API pro Microsoft Power BI

Abstrakt

Mnoho moderních softwarů nebo systémů zabudovává do svého jádra otevřená API a toto může být správná cesta vpřed. Tématem této diplomové práce je porovnání možností a rozšiřitelnosti moderních nástrojů pro analýzu dat (Google Data Studio, Qlik Sense, Microsoft Power BI, Tableau) pro integraci na základě API, licencování, výkonu a vývoj vlastních datových konektorů.

V teoretické části této práce byl proveden systematický přehled literatury o datové doméně, včetně systémové integrace, business intelligence, datové analýzy, datových typů, datových zdrojů a nástrojů pro analýzu dat.

V praktické části byla vyvinuta jako případová studie vlastní datový konektor s jazykem M v Microsoft Visual Studio s pomocí Power Query SDK pro vytvoření integrace mezi Microsoft Power BI a Adobe Captivate Learning Management System prostřednictvím Captivate Prime API.

Klíčová slova: systémová integrace, business intelligence, datová analytika, datový konektor, vývoj konektorů na zakázku, api, microsoft power bi

Table of Content

1. Introduction

The Ishango rod is recognized as the oldest mathematical tool for humanity, which is a 10-cm long curved bone carrying 168 engraved notches distributed in three columns along the bone length, most likely 22,000 years old (1) —suggesting that ancient cultures have collected data around the world by observing nature and the stars to predict and obtain the knowledge required for survival. Nowadays, companies collect and process data on a scale, mainly supporting their business decisions. Data products generate data to improve and optimize their usage and quality, such as self-driving cars, wearables, and drones.

"Data is the new oil" and *"Knowledge is power"* are two common refrains that have been quite popular over the last couple of decades and have generated a great deal of discussion. Some of those discussions focus on ownership, privacy, legal and ethical aspects of its usage, but the most significant one focuses on *"time."* Data has an expiration date based entirely on the speed and nature of its processor, which means that in a fast-pacing environment, it carries more value to gather critical business insights.

Analytics and business intelligence (ABI) platforms enable less technical users to model, analyze, explore, share and manage data, and collaborate and distribute findings, enabled by IT and augmented by artificial intelligence (AI). Numerous platforms are adding capabilities for users to compose low-code or no-code automation workflows and applications. However, the best BI tool is open for discussion and depends on the strategy, budget, size, technical knowledge, and audience.

Depending on the nature of the business, data, and sources, custom solutions meet specific needs. Custom visualizations help deliver high-impact data stories. Custom connectors help connect and access data from an application, service, or data source. Most BI tools tend to fail whenever trying to integrate with other web apps, force to use their products individually. This limitation often results in having multiple BI tools within one organization rather than having access to a single integrated solution.

Hence, it is critical to analyze the BI tools, their architectures, capabilities, and extensibilities when choosing. This thesis compares BI tools in that aspect and tries to develop a custom connector over a case study.

2. Objectives and Methodology

2.1. Objectives

The main objective of this thesis is to compare the capabilities and extendibility of modern-day data analytic tools for integration based on the APIs, licensing, performance, and custom data connector development.

The partial goals of the thesis are to compare some aspects of tools, create development environments, and develop a custom data connector for the selected tool and an external system.

2.2. Methodology

The theoretical part is based on the systematic literature review that provides an understanding of data and data analytics tools performed in the aspect of both data analysts and data engineers with the help of public surveys, research, websites, public market data, and other written or online sources.

Followed by explaining data types, connector, and their relations, the practical part will contain a comprehensive benchmark of data analytics tools and a custom data connector development case study over Microsoft Power BI to create a connection between the third-party system via API as an external data source.

3. Literature Review

3.1. Systems

A system is defined as combining elements that function together to produce the capability required to meet a need (2). In broad terms, a system can be explained as a collection of interconnected components that interact and rely on each other to perform a specific function. A system can be broken down into smaller subsystems or components, and a system can be one of the components in a more extensive system (3).

All systems have a principal function or a meaningful purpose, a hierarchical structure, interacting subsystems and components that interact with each other, a life cycle, and reliability (3).

3.1.1. Systems Engineering

At The National Aeronautics and Space Administration (NASA), systems engineering is defined as a methodical, multi-disciplinary approach to the design, realization, technical management, operations, and retirement of a system. The elements include all hardware, software, equipment, facilities, personnel, processes, and procedures needed for this purpose; that is, all things required to produce system-level results (2).

According to International Council on Systems Engineering (INCOSE), systems engineering is a transdisciplinary and integrative approach (4) to enable the successful realization, use, and retirement of engineered systems, using systems principles and concepts, and scientific, technological, and management methods (5).

The engineering of typical systems is a multi-disciplinary team activity requiring the application of a mix of hardware, software, and human engineering methodologies.

3.1.2. Systems Integration

Systems integration is the unification of the objects and their interactions of energy, matter, material wealth, and information to provide system-level functionalities and performances (6).

System integration for the infrastructure industry is the integration of systems within a project, not just the electrical, mechanical, architectural, and civil systems, but also all technical and human elements, which emphasizes a holistic view, focusing on projects and the systems they are delivering as a whole (7).

A working group of industry associations, INCOSE, and the US Department of Defense created an interim standard for system engineering in June 1994 (8). Although there is no such thing as a singular fact of systems engineering that is widely accepted as a standard practice today, regardless of their differences, various systems engineering variants (2), (5), (8) have shown to be highly effective in the production of goods and services.

3.2. Hypertext Transfer Protocol (HTTP)

HTTP is a generic, object-oriented, extensible, stateless application-layer protocol for transmitting information between networked devices through the extension of its request methods (9). It is considered the foundation of any data exchange on the Web (10). In the client-server model, HTTP functions as a request-response protocol.

3.2.1. HTTP Authentication

HTTP supplies a broad framework for access control and authentication via an extensible set of challenge-response authentication schemes, which a server can use to challenge a client request, and a client can use to provide authentication information.

The general HTTP authentication framework is the base for several authentication schemes. The "Basic" HTTP authentication scheme transmits credentials encoded using base64 as username/password pairs (11). The "OAuth" protocol is a token-based architecture that relies on the fact that all services receive a token as verification that the application is authorized to call the service (12). The "Bearer" token can also be used to access OAuth 2.0 protected resources without providing a cryptographic key (13).

Figure 1 Basic HTTP Authentication Sequence
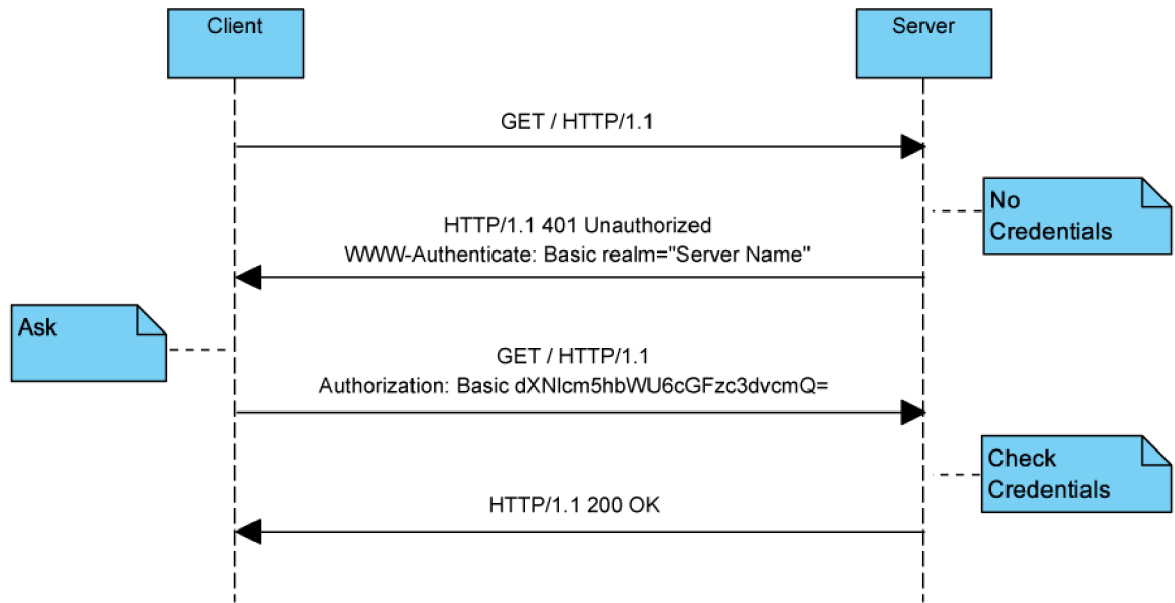
3.2.2. HTTP Response Status Codes

HTTP response status codes point out whether a specific request has been successfully completed. These status codes are defined by RFC 1945 in 1996 (obsolete version 1.0), updated by RFC 2616 in 1999, and by RFC 7231 in 2014.

HTTP response status code is a three-digit integer code representing the result. Initial digit of the status code defines its class which all of them listed in the protocol releases. There are non-standard response codes available depending on the server's custom software.

Table 1. List of HTTP Response Status Code Groups

Class	Interval	Category	Description
1XX	100-199	Informal	The request was received, continuing process.
2XX	200-299	Successful	The request was successfully received, understood, and accepted.
3XX	300-399	Redirection	The request needs further action to be taken for its completion.
4XX	400-499	Client Error	The request contains bad syntax or cannot be fulfilled.
5XX	500-599	Server Error	The request cannot be fulfilled due to server failure.

Source: (9), (14), (15)

3.2.3. HTTP Request Methods

HTTP defines methods to stipulate the desired action to be performed on the identified resource. The first version of HTTP/0.9 had only supported the "GET" method. HTTP/2 does not affect the existing methods of HTTP/1 (16).

Table 2. Properties of HTTP Request Methods

Method	Has Body	Successful Response Has Body	RFC
GET	Optional	Yes	RFC 7231
HEAD	Optional	No	RFC 7231
POST	Yes	Yes	RFC 7231
PUT	Yes	Yes	RFC 7231
PATCH	Optional	Yes	RFC 5789
DELETE	Optional	Yes	RFC 7231
CONNECT	Optional	Yes	RFC 7231
OPTIONS	No	Yes	RFC 7231
TRACE	Yes	Yes	RFC 7231

Source: (15), (17)

3.3. Application Programming Interface (API)

An application programming interface (API) is a software-to-software interface that defines the contract for applications to talk to each other over a network without user interaction (18).

APIs allow businesses to expose the data and functionality of their apps to third-party developers, business partners, and internal stakeholders within their organizations. Through a specified interface, this allows services and products to communicate with one another and benefit one another's data and capability.

3.3.1. API Types

APIs are mainly classified into three or four main different types based on design and purpose by technology leaders such as Red Hat (19), IBM (20), and Amazon (21): Public or Open APIs, Partner APIs, Internal APIs, Composite APIs.

APIs can be broadly listed under two types: Public APIs, open to all for use; Private APIs, accessible by restriction.

3.3.2. API Architectures

API architecture refers to the technical framework of developing a software interface that bares backend data and application functionality. An API architecture consists of elements for external interfacing, traffic control, runtime execution of business logic, and data access.

3.3.2.1. Remote Procedure Call (RPC)

This protocol is the most straightforward, which enables the client to execute a function or procedure on the server, and the server sends the output back to the client.

3.3.2.2. Simple Object Access Protocol (SOAP)

SOAP was designed as an object-access protocol and released as XML-RPC (22). This protocol built with XML enables users to send and receive data through SMTP and HTTP.

3.3.2.3. Representational State Transfer (REST)

REST is not a protocol but a style, which is a set of web API architecture principles. REST defines a set of functions that clients can use to access server data over HTTP. The main feature is that servers do not save client data between requests.

3.3.3. API Security

APIs provide access to valuable and protected data and assets. Therefore, security for APIs is of utmost importance to protect the underlying assets from unauthenticated and unauthorized access (18).

Very few API providers offer APIs that do not require any type of identification. Most APIs use one or more of the following fundamental security techniques. Authentication and authorization are two foundation elements of security and are both common terms in the world of identity and access management (IAM). In simple terms, authentication is the process of verifying who a requester is, while authorization is the process of verifying what they are capable of or access to.

Figure 2 OAuth 2.0 protocol access token grant flow

User (Resource Owner)	API Provider (Authorization Server)	Application (Client)
	Prompt user to provide authorization	Direct user to API provider for authorization
		Request params: - scope - client_id
User authorizes application access	Redirect user to redirect_url, passing code	Exchange the code for an access token
		Request params: - code - client_id - client_secret
	Grant an access token	User access token to access protected resources

3.4. Business Intelligence (BI)

Business Intelligence has multiple definitions in multiple publications, and it is a broad term that encompasses collecting, storing, and analyzing data activities.

BI as a term includes the strategies, processes, applications, data, products, technologies, and technical architectures used to support the collection, analysis, presentation, and dissemination of business information (24). BI combines business analytics, data mining, data visualization, data tools and infrastructure, and best practices to help organizations make more data-driven decisions (25).

BI helps organizations analyze and swiftly extract meaningful, actionable insights from historical and current data to make strategic decisions (26).

3.4.1. Data Analytics

Data analytics is a discipline that has the administration of the whole data lifecycle, which includes data collection, cleaning, organization, storage, analysis, and governance (27). It focuses on gathering insights from data, which might be structured, unstructured, or somewhere in between.

Data analytics contains four main categories (27) that assist in answering diverse questions based on approaches, algorithms, and, most importantly, the outcome. However, the best type of data analytics for a business is heavily dependent on its data strategy.

3.4.1.1. Descriptive Analytics

Descriptive data analytics is considered the foundation of reporting, which examines historical events in detail to answer questions focused on where, when, what, and quantities.

3.4.1.2. Diagnostic Analytics

Diagnostic data analytics, also known as root cause analysis, benefits data to uncover the causes of problems, patterns, and correlations to answer questions that seek to determine why something happened.

3.4.1.3. Predictive Analytics

Predictive analytics focuses on determining the likelihood of future outcomes using historical data combined with statistical algorithms, data mining, and machine learning (ML) techniques. It enriches information with meaning to develop knowledge that explains how that information is connected.

3.4.1.4. Prescriptive Analytics

Prescriptive analytics builds upon the results of predictive analytics to determine an optimal course of action. The focus is not just on which suggested choice is the best to pursue but also on why.

3.4.2. Data Analysis

Data analysis is the process of scrutinizing data to describe and illustrate by systematically applying statistical techniques to support making better-informed decisions.

3.4.3. Data Types

The data type is key for data analysis and predictive modeling since it helps select the sort of data visualization, data analysis, or statistical model.

3.4.3.1. Quantitative Data

Quantitative data is information expressed on a numeric scale that can be counted or measured. Quantitative data can be in a discrete form that represents data as a whole such as in integers, or in a continuous form that represents data measured over a specific interval, such as complex numbers.

3.4.3.2. Qualitative Data

Qualitative data is information expressed in typically nonnumerical form, like a specific set of values representing a set of categories. Qualitative data can be in a binary form representing data with just two categories of values, such as true/false or 0/1, or ordinal form representing data with an explicit ordering.

3.4.4. Data Storage Types

3.4.4.1. Structured Data

Structured data represents highly organized, factual data that has been predefined and formatted to a specific data model, schema, or structure prior to being saved in a storage such as relational databases (27). Being easily consumed and interpreted by users, easy manipulation, and accessibility are some of the advantages of structured data. However, a predefined structure limits the usage and flexibility, and storage requires special systems, which are also limited. Structured data is typically classified as quantitative data.

3.4.4.2. Unstructured Data

Unstructured data represents data that does not have a predefined model but is stored in its native format. It can be textual or binary and best managed in non-relational databases. The native format enables it to be prepared and analyzed by only needed parts, and it can be collected quickly and effortlessly without a schema. On the other hand, it requires some level of expertise and specialized tools for manipulation. Structured data is typically classified as qualitative data.

3.4.4.3. Semi-structured Data

Semi-structured represents such data with a defined structure level but is not relational. Instead, semi-structured data is hierarchical or graph-based, making it more challenging than structured data but less difficult to store than unstructured data.

3.4.5. Data Sources

A data source is the location of obtained information, simply the source of data, which can be a file, a particular database, scraped web data, or even a live data feed. It might be located on the same computer or another computer somewhere on a network.

Data can be obtained directly from files (such as Text/CSV files, Excel Workbooks, JSON files, XML files, PDF files, and Parquet files, etc.), or relational or non-relational databases (such as SQL Server database, Access database, PostgreSQL database, SAP HANA, Amazon Redshift, Snowflake, and MariaDB, etc.), or online services (such as Dynamics 365, Salesforce Reports, Google Analytics, GitHub, and Adobe Analytics, etc.), or other data sources (such as web, OData Feed, Spark, R, Python, ODBC).

3.5. Business Intelligence Tools

As the variety of business intelligence tools increases in the market, what makes the best of them heavily depends on the needs and scope of the project and strategy. Licensing, budget, operation size, technical infrastructure, technical knowledge, stakeholders' profile as end-users, variety of data sources, integration capabilities, and most importantly, time for setup, maintenance, and analysis might help for decision.

New generation platforms mostly include key features such as data visualization, visual analytics, dashboarding, utilization of automated reporting, predictive analytics features based on self-services that allow for consumption and investigation of the insights of the data by adding investigation capabilities such as drilling, paging, filtering, selecting, and crossing information from multiple sources.

3.5.1. Google Data Studio

Google Data Studio is one of the integrated solutions for Google Marketing Platform (28), a free tool that converts data into informative, easily readable, shareable, and fully customizable dashboards and reports.

In 2016 (29), it was first introduced as a new data analysis and visualization tool that integrates data across all suite products and additional data sources. Since, it has been quite popular mainly because of being free and integrated with other Google services and products, handling data authentication, access rights, and leveraging teamwork.

It enables users to access a wide variety of sources via built-in and partner connectors, making it feasible to connect to virtually any kind of data without programming (30). Data Studio has 20 Google Connectors built and supported by Google for Google Services such as BigQuery, Campaign Manager 360, Google Ad Manager 360, Google Analytics, Google Ads, Google Surveys, YouTube Analytics, Search Console, and other popular sources such as MySQL, PostgreSQL, Amazon Redshift, Microsoft SQL Server. It provides great integration opportunities with over 500 partner connectors built and supported by Data Studio partners (31).

Data Studio provides highly configurable charts and tables such as Bar Chart, Line Chart, Scorecard, Slider, Gauge, Candlestick, and Waterfall to turn data into compelling stories of data visualization art. It also has more than 30 partner visualizations built and supported by Data Studio partners such as Gantt Chart, Radar Chart, Sunburst, Cards View, Animated Bar Chart, Date Picker, and Heatmap (32).

Google Report Gallery also has easy-to-use and inspirational templates, more than 40 officially built by Data Studio Team and more than 120 built by partners (33).

In terms of extendibility and customization, it is possible to create a custom connector with App Scripts (34) and custom visualization with any visualization library with JavaScript and CSS (35).

3.5.2. Qlik Sense

Qlik Sense is an AI-fueled BI reporting and analytics platform (36) that allows users to collect, merge, and process diverse data from many data sources, gather business-critical insights, and deliver the information to the organization in a readily consumable format.

The first version was named QuickView, known as QlikView, in 1996 (37) Since then, Qlik has focused on business intelligence and invested in its product family. Nowadays, Qlik Sense is positioned under the analytics services in Qlik Cloud architecture, integrated with Qlik Data Integration and Qlik Application Automation. This architecture allows flexible deployment options that protect data location and local governance needs (38).

Qlik Sense allows connecting the data, wherever it resides, with a wide range of Qlik Connectors and other data connection types, such as attached files, Essbase dataset, local or network files, web files, SAP, Salesforce. It has database connectors such as Amazon Athena, Amazon Redshift, Apache Spark, Azure SQL, Azure Synapse, Databricks, Google BigQuery, MongoDB, PostgreSQL, MySQL, Oracle, and Snowflake. Qlik Web Connectors with a separate installation allows connecting to social media or web-based data sources, such as Amazon S3, Azure Storage, Box, Dropbox, Facebook Insights, GitHub, Google Analytics, JIRA, Outlook 365, Twitter, and YouTube Analytics (39).

Qlik Sense provides standard visuals, such as Bar Chart, Box Chart, Bullet Chart, Combo Chart, Distribution Plot, Filter Pane, Gauge, Histogram, KPI, Line Chart, Map Chart, Mekko Chart, Pie Chart, Pivot Table, Scatter Plot, Table, Text & Image, Treemap, and Waterfall Chart (40). It also provides a set of charts that can be used to enhance and increase the Qlik Sense app's charting capacity, such as Bullet Chart, Funnel Chart, Grid Chart, Heatmap, Multi KPI Chart, Network Chart, Org Chart, P&L Pivot Chart, Radar Chart, Sankey Chart, Trellis Container, Variance Waterfall Chart, and Word Cloud Chart (41).

The QVX SDK allows the development of custom connectors in Qlik Sense, enabling connections to data sources that are not directly supported (42). It is also possible to create

new ways of visualizing data and enhance user input and interaction with Qlik Sense custom visualization extensions (43).

Figure 3 Qlik Active Intelligence Platform
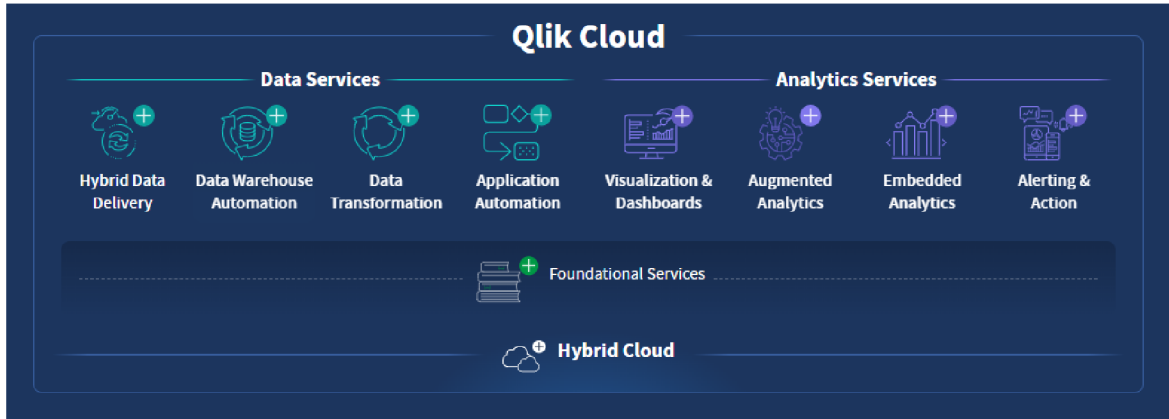
Source: (38)

3.5.3. Microsoft Power BI

Power BI is a cloud-based technology from Microsoft to deliver business intelligence solutions (44). It is a collection of software services, apps, and connectors that are seamlessly integrated with each other for turning data into coherent, visually immersive, and interactive insights (45).

It was created as *"Project Crescent"* and introduced as *"a stunning new data visualization experience"* in 2010 (46). Renamed "Power BI", it was publicly available as *"a powerful new visual data exploration and interactive reporting tool"* in mid-2015 with many features such as globally available in 44 languages, new style, enhanced data transformation and mashup capabilities, and REST API (47).

The architecture is built on top of components responsible for a specific part of the technology. Power BI Desktop is a Windows-based desktop free application primarily for designing and publishing reports to the Power BI Service (48). Power BI Service is a SaaS-based online service (44). Power BI Mobile provides insights anywhere (49) with applications for mobile devices on App Store (50), Windows Store (51), and Google Play (52). Power BI Gateway component is specifically for syncing external data in and out of Power BI and is required for automated refreshes (44). Power BI Embedded provides white-labeling and uses Power BI within the custom applications (53). Power BI Report Server is

an on-premises reporting solution for enterprises that will not or cannot store data in the cloud-based service, with the flexibility to move to the cloud at any time (54). Power Query is the data transformation and mash-up engine which connects different types of data sources, applies transformations, and loads the data. It was created for Excel consumers instead of using SQL (55). DAX and modeling are the analytical core and engine of Power BI. DAX language is for writing calculations in Power BI, Excel Power Pivot and SQL Server Analysis Services Tabular Model (44).

Power BI's Get Data feature allows consumers to select from a range of data sources from on-premises to cloud-based, unstructured to structured. It is seamlessly integrated with other Microsoft products, such as Azure Databricks, Azure Synapse, Azure Data Lake Storage, Azure Blob Storage, SharePoint Folder and List, Excel, SQL Server, and other sources such as MySQL, PostgreSQL, Snowflake, OData, ODBC, Oracle, Amazon Redshift, R Script, Python Script (56).

Power BI offers a broad selection of detailed and engaging visualizations readily available on the visualization pane, such as Bar Chart, Line Chart, Area Chart, Map, Funnel Chart, Gauge Chart, Ribbon Chart, etc. It is also possible to import visuals from Microsoft AppSource (57), such as Radar Chart, Tornado Chart, Gantt Chart, Sunburst, Box and Whisker Chart, and Sankey Chart (58).

Power BI offers reporting samples for mainly inspiration and demonstration for different purposes, such as *"Sales and Returns sample"* for demonstrating many new features, *"Eight original samples"* with each sample representing a different industry, and *"COVID-19 US sample"* to analyze and visualize the pandemic data (59).

There are SDKs that developers can work with: an SDK for creating custom visuals or another SDK for creating custom connectors in Visual Studio. In case of none, the available standard and marketplace visualizations meet the specific needs, it is possible to develop custom Power BI visuals to be used by inside organizations or the entire Power BI community (60). Power Query SDK provides an M language service for Visual Studio and a framework (61), allowing developers to build a custom connector for Power BI, which can be only available in Power BI Desktop and Power BI Service through the use of an on-premises data gateway (62).

Figure 4 All Components of Power BI
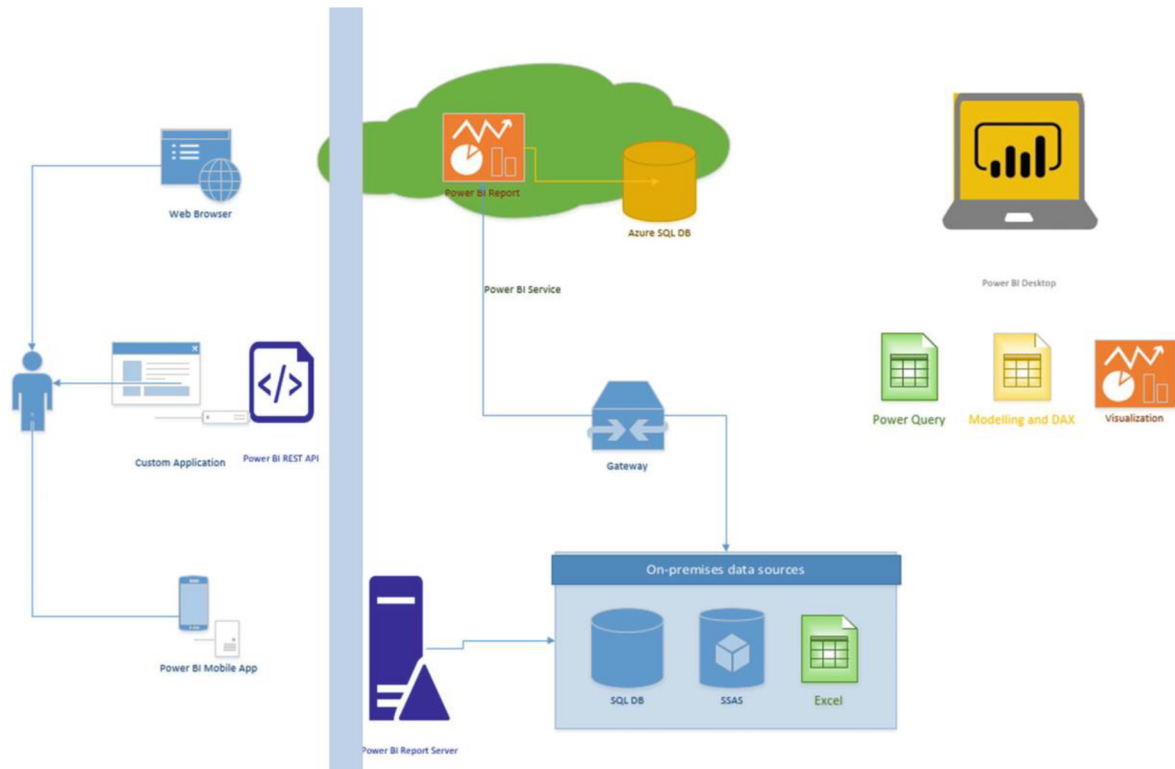
Source: (44)

3.5.4. Tableau

Tableau is a visual analytics platform. It provides a visual exploration experience that allows business users to access, prepare, analyze, and display data discoveries (63).

It was established in 2003 as an outcome of a computer science project at Stanford to improve the flow of analysis and make data more accessible to people through visualization (64). In 2019, Salesforce announced that it had completed the acquisition of Tableau Software (65).

The product line of Tableau supports the full cycle of self-service analytics from prep to analysis to sharing, with governance and data management every step of the way. Tableau Prep provides a visible and straightforward approach to integrating, shaping, and cleaning data, as well as automating data prep flows, allowing for quicker analysis and insights (66). Tableau Public is a free platform to explore, create and publicly share data visualizations online (67). Tableau Desktop allows unrestricted data exploration via an easy interface, stimulating curiosity, creativity, and data-driven decision-making (68). Tableau Server

extends the value of data across the entire organization via governed self-service analytics at scale, either on-premises or in a public cloud (69). Tableau Online provides self-service analytics in the cloud without the responsibility of managing and maintaining the infrastructure (70). Tableau Mobile acts as a window into Tableau Server or Tableau Online from wherever or whenever via its mobile applications on Apple Store (71) and Google Play (72). Tableau CRM (formerly Einstein Analytics) empowers Salesforce CRM users with actionable insights and AI-driven analytics right in the workflow (73).

Tableau lists over 90 connectors for how to connect specific data from simple sources such as text files, Microsoft Excel, JSON files, spatial files, and other files to other systems such as Salesforce, Tableau Server or Tableau Online, Amazon Redshift, Google Analytics, MariaDB, MySQL, OData, Oracle Eloqua, PostgreSQL, other JBDC and ODBC databases (74). Tableau Exchange enables Tableau to access additional databases and applications via Partner-Built Connectors such as Linkedin, Oracle NetSuite, Agiloft, Couchbase Analytics, Rockset, Salesforce Datorama, Yellowbrick, Dremio (75).

Tableau offers the most common types of Charts such as Pie, Bar and Line Charts, Treemaps, Histogram, Scatter Plot, Bullet Graph, Box & Whisker with advanced Geo-location charts like Proportional Symbol Maps and Choropleth, Isopleth and Area Maps (76). Tableau Exchange helps add new functionalities to dashboards using web applications via dashboard extensions such as Quick What-If, Date Range Picker, Einstein Discovery, Bar Race, Process Analysis, ProcessMining, DrillDownTree, Chart Data Extractor, Image Map Filter, Brush Filter, Super Tables, Semiotic Hierarchy, Animated Bubbles (77).

Although connectors from the Tableau Exchange are not currently supported for use with Tableau Bridge (78), Tableau provides the capabilities for creating a customized connector via Tableau Connector SDK for Tableau Desktop. Tableau Connector SDK is appropriate for connecting to an ODBC or JDBC driver that interfaces using SQL (79). The Tableau Dashboard Extensions API enables developers who want to build a custom visualization via Tableau extensions which are web-based apps that interact and communicate with Tableau (80).

Figure 5 The Tableau Platform
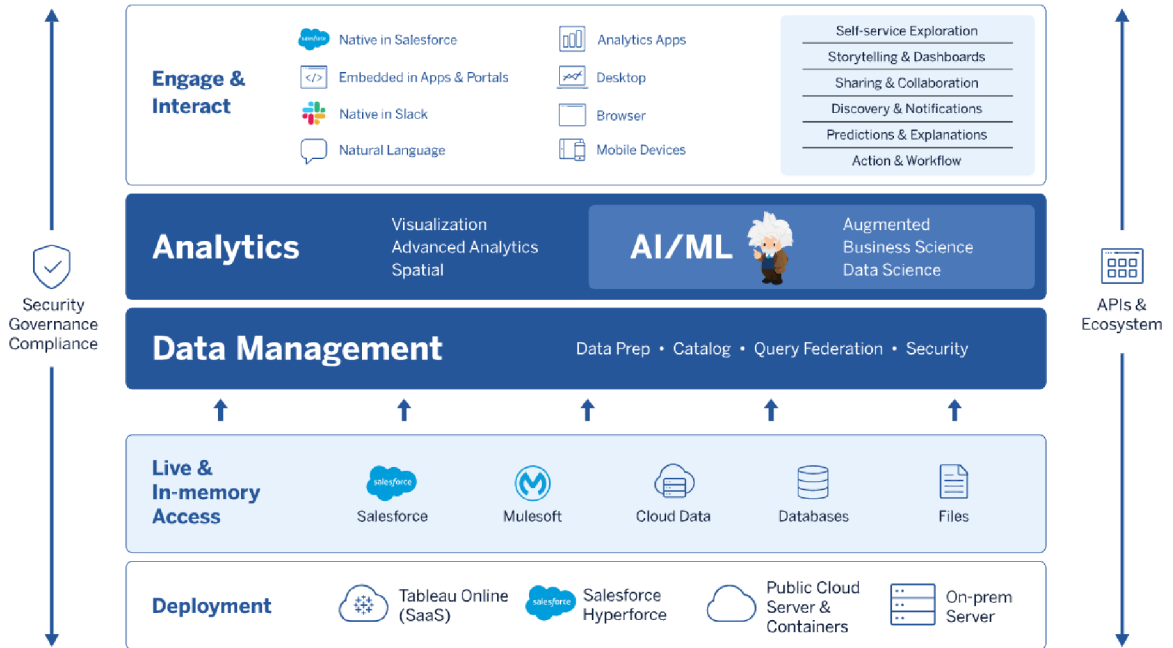
Source: (81)

3.5.5. Gartner Report for Analytics and Business Intelligence Platforms

Gartner defines Magic Quadrant as "a culmination of research in a specific market, giving you a wide-angle view of the relative positions of the market's competitors" (82).

Magic Quadrants use standard criteria in two categories: Completeness of Vision and Ability to Execute, which are backed up with a selection of sub-criteria to clarify how the standard criteria apply specifically to the market being evaluated.

Ability to execute includes the following standard criteria: products and services, overall viability, sales execution/pricing, market responsiveness and track record, marketing execution, customer experience, and operations. Completeness of vision includes the following standard criteria: market understanding, marketing strategy, sales strategy, offering strategy, business model, industrial strategy, innovation, and geographic strategy (83).

Figure 6 The Magic Quadrant
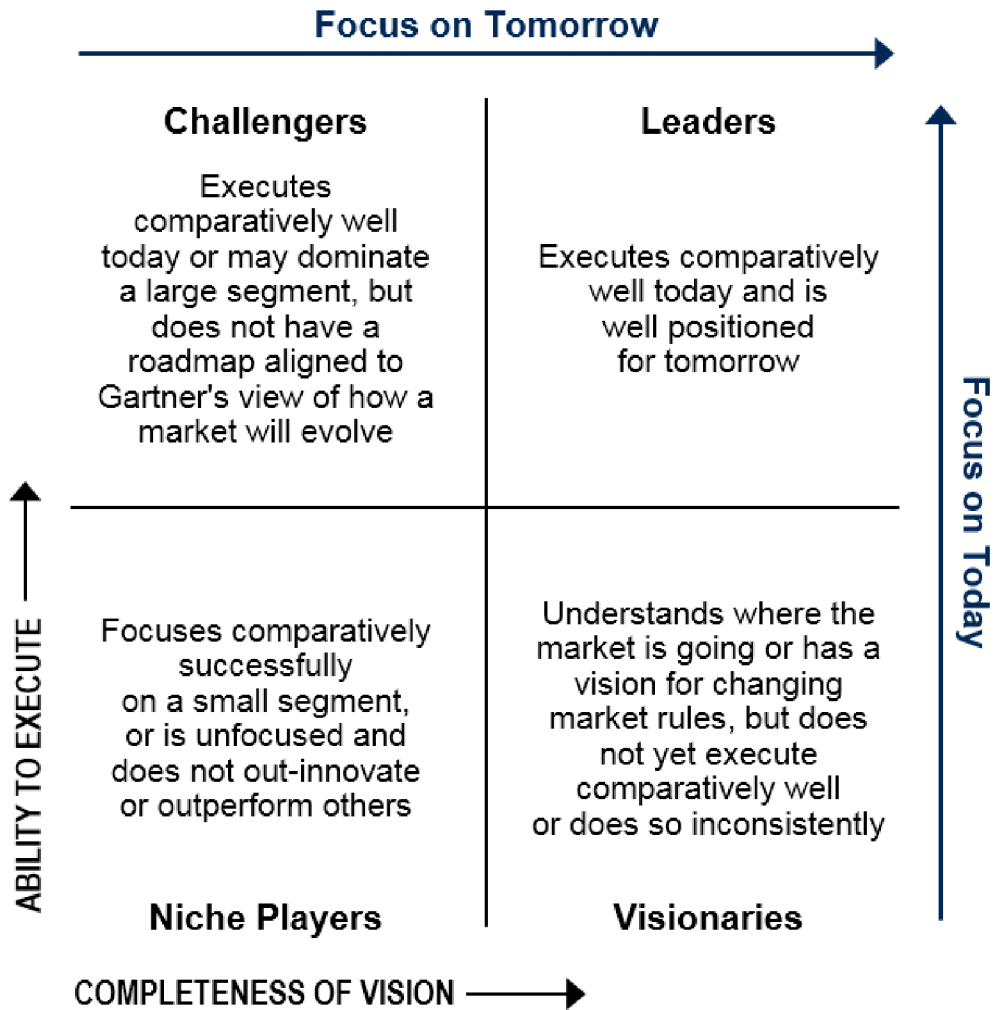
Source: (83)

3.5.5.1. Magic Quadrant for Analytics and Business Intelligence Platforms

Analytics and business intelligence platforms are distinguished by easy-to-use functionality that supports a full analytic workflow, from data preparation to visual exploration and insight generation, emphasizing self-service usage and augmented user assistance. This platform functionality includes the following 12 critical capability areas, which have been updated to reflect areas of change and differentiation, particularly in capabilities more closely associated with augmented analytics: security, governance, cloud-enabled analytics, data source connectivity, data preparation., catalog, automated insights, data visualization, data storytelling, natural language query, natural language generation and reporting (84).

31

Figure 7 Magic Quadrant for Analytics and Business Intelligence Platforms

In 2020, after Salesforce's acquisition, Tableau enhanced its data preparation and data management capabilities (85). With the highlighted strengths of business user-centric, analytics economy and, Salesforce ecosystem opportunity, Tableau is recognized as a leader by Gartner in 2022 (84).

After the acquisition of NodeGraph and Big Squid, Qlik added more capabilities to its extensive portfolio of acquisitions. Qlik launched a no-code solution that allows users to automate tasks and data workflows called *"Qlik Application Automation"*. With the highlighted strengths of flexibility of deployment, expanding portfolio of capabilities and customer engagement and data literacy programs, Qlik is recognized as a Leader by Gartner in 2022 (84).

Currently, Microsoft dominates the market (85) in terms of user adoption, according to Gartner's report. Microsoft releases a weekly update to its cloud-based Power BI service, which gained hundreds of features in 2021. With the highlighted strengths of alignment with Office 365, Teams and Azure Synapse, price/value combination, and power portfolio and product ambition, Microsoft is recognized as a leader by Gartner in 2022 (84).

3.6. Learning Management Systems

In the late 1980s, the first kind of electronic education, Computer-Based Training (CBT), was established and is considered the foundation of the modern concept of online learning, often referred to as eLearning (86).

A learning management system (LMS) is a software application used to manage educational courses, training programs, or learning and development programs by tracking, reporting, automating, and delivering them (87). It covers everything needed to create and deliver virtual training courses to students, employees, partners, clients, or anybody who needs to catch up on complicated subjects.

Broadly classifying, there are two main categories of learning management systems. Education-focused LMSs are designed to be used by educational institutions, such as K-12 schools, colleges, universities, and professional schools. Some of the highest-rated education-focused LMSs are Google Classrooms, Docebo, CanvasLMS, Schoology, Cornerstone, and Moodle (88).

Corporate LSMs are designed to be used by businesses for training employees, customers, or external partners. Some of the highest-rated corporate LMSs are Paylocity, Lessonly by Seismic, Paycore, Trainual, Thinkific, and Adobe Captivate Prime (89).

3.6.1. Adobe Captivate Prime

Adobe Captivate Prime is a cloud-hosted, learner-centric, and self-service learning management solution. Adobe enables enterprises with the existing LMSs to migrate their organization's training data and content to the Captivate Prime LMS application (90).

3.6.1.1. Position in Corporate LMS Market

G2 scores products, platforms, and merchants based on reviews and feedback gathered from its community, as well as data gathered from online sources and social networks. Final scores are calculated by both satisfaction ratings based on customer satisfaction data from real user reviews and market presence scores combined with more than 15 data points (91).

As a next-gen LMS that delivers personalized learning experiences across multiple devices, Adobe Captivate Prime is named one of the leaders in corporate LMS software by G2 Crowd.

Figure 8 Adobe Captivate Prime positioning as Leader in G2 Grid
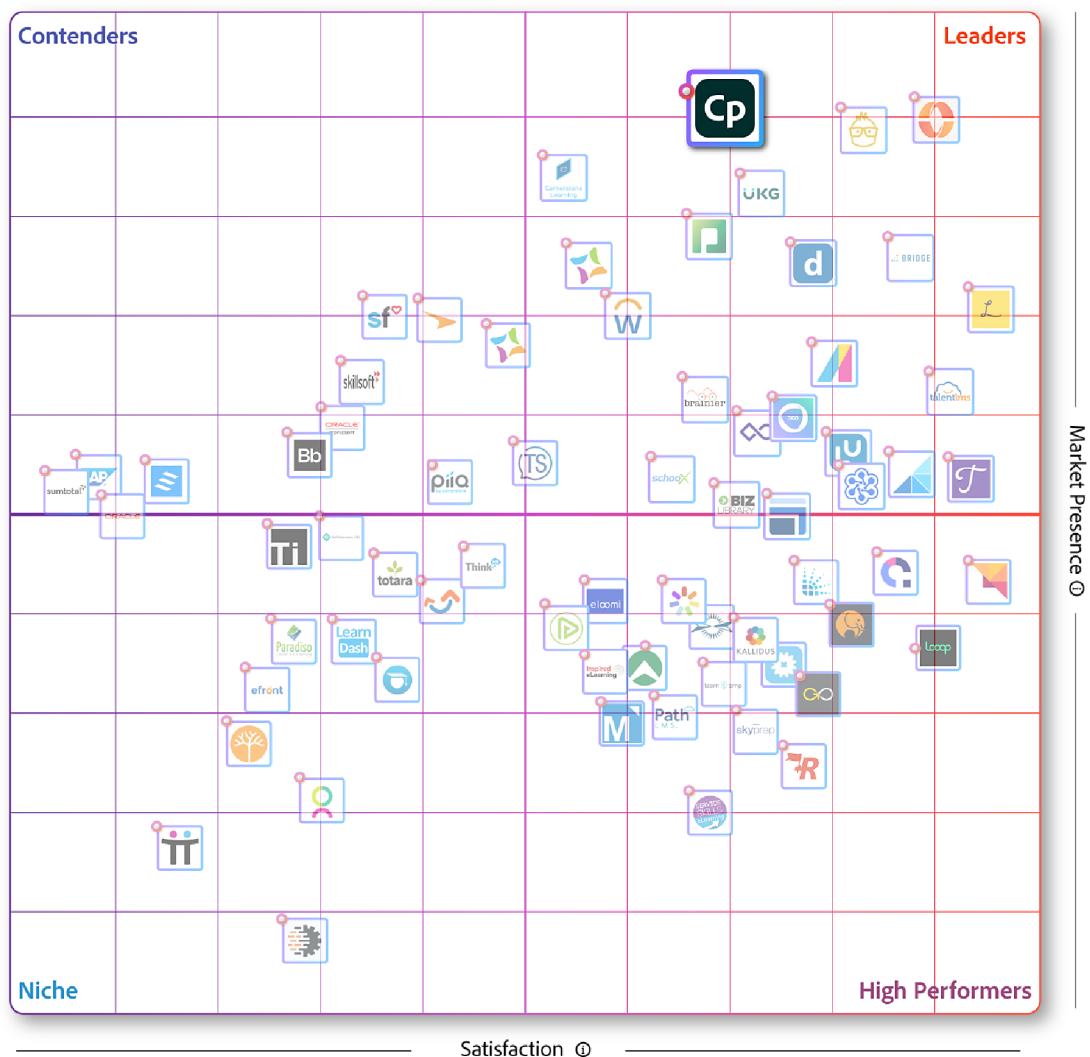
Source: (92)

3.6.1.2. Awards

Having rich features like Single Sign-On (SSO) integration that enables enterprise login, user management covers internal and external users with a segregated view, badges to motivate the users at every milestone, enhanced gamification on the learning journey, a content marketplace with 70,000 courses, integrations with external systems, learning paths, learning plans, learning summaries, learner transcripts, scheduled notifications, role-based reporting, customized experiences, multi-tenancy, xAPI support, next-generation data visualization tools, AI-powered training recommendations, automated learning plans, course-feedback reports, recurring certifications and native branding (93), Adobe Captivate Prime got awarded in multiple categories over the years.

Table 3. Adobe Captivate Prime LMS Awards in 2021

Rank	Awarded By	Award Category
#1	eLearning Industry	in Top Gamification Learning Management Systems
#2	eLearning Industry	in Top Gamification Learning Management Systems
#2	eLearning Industry	in Top LMS with Video Conferencing Integration
#2	eLearning Industry	in Top LMS for Product Training
Finalist	SIIA	in best Customer Training LMS Category
#2	eLearning Industry	in Top LMS Training Software with Learning Analytics Tools
#14	G2 Crowd	in Best HR Products
#1	eLearning Industry	in Best LMS Software to Use When Working Remotely
#34	G2 Crowd	in Best Small Business Products
#1	eLearning Industry	in Top Cloud-Based LMS for Corporate Training
#25	G2 Crowd	in Best Enterprise Products
#69	G2 Crowd	in Best Software Products

Source: (94)

3.6.1.3. Captivate Prime Connectors

Captivate Prime connectors are tools that facilitate data-based connections, such as intaking data from other systems into Captivate Prime and exporting data from Captivate Prime to external systems.

Salesforce, Captivate Prime FTP, getAbstract, Harvard ManageMentor, Box, Workday, BlueJeans Event, Power BI, LinkedIn, ADFS, BlueJeans Meeting, Zoom, Custom

FTP, Adobe Connect, Marketo Engage, Microsoft Teams are listed (95) as available connectors and officially supported external systems by Adobe.

3.6.1.4. Captivate Prime APIs

Captivate Prime has a set of APIs to integrate enterprise applications with the Captivate Prime LMS (96). The Captivate Prime APIs are based on REST principles and exposes key elements of the Captivate Prime Object Model to application developers through HTTP (97).

Table 4. Available Captivate Prime APIs for available roles

	badge	catalog	misc	skill	user	user group	learning object	enrolment profile	job	board	post	comment	reply	social profile
Learner	X	X	X	X	X	X	X		X	X	X	X	X	X
Admin	X	X	X	X	X	X	X	X	X					

Source: (96)

3.7. Power Query & M Language

Power Query is a data transformation and data preparation engine (98), as it has been defined in the official documentation. The core data preparation experience is the Power Query Editor, providing connections to a variety of data sources, and applying hundreds of various data transformations by previewing data and applying transformations from the UI.

Some transformations cannot be performed optimally using a graphical editor in any data transformation scenario. Some of these conversions may involve unique configurations and settings that the graphical interface may not allow.

The Power Query engine uses a scripting language behind the scenes for all Power Query transformations: the Power Query M formula language, also known as M. The M language is the data transformation language of Power Query. Everything that occurs in the

query is ultimately written in M. Each of the roughly 700 functions is covered in detail in the Power Query M function reference (99).

M is a case-sensitive, functional programming language. Query Folding and Lazy Evaluation are two of M's engine's top performance and scalability characteristics. If feasible, M queries created in Power BI Desktop are folded into SQL statements and sent to source systems for processing. M may also decrease the number of resources required for a particular query by avoiding any superfluous steps or redundant variables (100).

Table 5. Microsoft products and services where Power Query is available

Product	M Engine	Power Query Desktop	Power Query Online
Excel for Windows	Yes	Yes	No
Excel for Mac	Yes	No	No
Power BI	Yes	Yes	Yes
Power Apps	Yes	No	Yes
Power Automate	Yes	No	Yes
Azure Data Factory	Yes	No	Yes
SQL Server Integration Services	Yes	No	No
SQL Server Analysis Services	Yes	Yes	No
Dynamics 365 Customer Insights	Yes	No	Yes

Source: (98)

4. Practical Part

4.1. Benchmarking of Data Analytics Tools

Power BI, Tableau and Qlik are popular choices in the market also named as leaders (82) in many sources (101). Following part compares them in following criteria: licencing and prices, data connectivity, visualizations, management, augmented and embedded analytics, mobile functionality, deployment options, custom connectors and visualizations, community, learning, support options and certification.

4.1.1. Licencing & Prices

Power BI, Tableau, and Qlik Sense offer different tiers in their licensing to suit different requirements. Although they all provide free trials and quoted custom pricing, Microsoft is the only one offering a free version, and tableau stands out as the most expensive one. The total cost of ownership (TCO) depends on the deployment strategy, data governance, developer and user count, data size, and hidden costs.

Table 6. Comparison of licensing options and pricing of data analytics tools

Platform	Licencing Type	Plan Name	Price*	Bill Cycle
Power BI (102)	Per User	Power BI Desktop	Free	N/A
	Per user	Power BI Pro	9.90	Monthly
	Per user	Power BI Premium	20.00	Monthly
	Per capacity	Power BI Premium	4995.00	Monthly
Tableau (103)	Per user	Creator	70.00	Annually
	Per user	Explorer	42.00	Annually
	Per user	Viewer	15.00	Annually
Qlik Sense (104)	Per user	Business	30.00	Annually
Prices are shown in USD/Monthly for marketing purposes only and may not be reflective of the actual list price due to currency, country, and regional variant factors.				

4.1.2. Data Connectivity

Power BI, Tableau, and Qlik Sense are deployed with many native connectors allowing users to connect to various existing data sources. Power BI ranks ahead of others in terms of officially supported data sources.

Table 7. Comparison of officially listed data connectors of data analytics tools

Platform	Data Sources*
Power BI (56)	136
Tableau (74)	90
Qlik Sense (105)	114
Data sources are listed in the official documentation. Some data sources may be available only in certain tiers.	

4.1.3. Visualizations

Power BI, Tableau, and Qlik Sense are deployed with built-in visualizations particularly useful for specific data types. Power BI offers to deploy visualizations for the entire organization. Qlik has a unique data engine that powerfully compresses large data sets and differs from SQL database-powered tools. Tableau stands out with automatic dashboard creation for popular sources and built-in animations.

Table 8. Comparison of officially listed visualizations of data analytics tools

Platform	Visualizations*
Power BI (106)	31
Tableau (107) (108)	20
Qlik Sense (40)	20
Supported visualizations in official documentation may depend on the version and deployment options.	

4.1.4. Data Management

Power BI, Tableau, and Qlik Sense provide blending, exploration, modeling, data prep, and multidimensional data analysis, which are at the top of comparing information management capabilities. However, it may require additional license tiers or products depending on the platform.

4.1.5. Augmented Analytics

Power BI, Tableau, and Qlik Sense benefits AI and ML technologies to automatedly support users on data management, exploration, analysis, and prediction process. Power BI (109) offers multiple artificial intelligence solution to its users with the power of Azure

services that is available with different license types. Tableau's *"Einstein Discovery"* interactively works (110) in workbooks and provide predictions of given data set on request. Qlik Sense has an Insight Advisor (111) that analyses the given dataset based on natural language questions and suggest visual insights which user can inspect and edit.

4.1.6. Embedded Analytics

Adding analytics to custom software or service without building an in-house tool is possible via embedded capabilities. Power BI (53) with a playground (112) to learn and explore, Tableau (113), and Qlik Sense (114) are robust solutions that provide white labeling and customization while embedding dashboards and supporting multi-tenancy. Nucleus Research lists (**Error! Reference source not found.**) Tableau as a leader and Power BI as a facilitator in the embedded analytics technology value matrix report (101).

4.1.7. Mobile Functionality

Mobile applications allow data consumers to access dashboards and reports regardless of device type. Power BI, Tableau, and Qlik Sense have mobile applications available and support dashboard customizations for mobile view. Qlik Sense provides (115) a full-native app offering fully interactive online and offline exploration. Power BI (49) and Tableau (116) have limited capabilities to perform edits.

4.1.8. Deployment Options

Power BI only runs on Microsoft Azure (117) solution. Tableau (118) and Qlik provide a full enterprise SaaS solution with on-premises or cloud options. Qlik offers private cloud options with total freedom and control over data.

Table 9. Comparison of deployment options of data analytics tools

Platform	On Premise	Hybrid	On Cloud
Power BI (117)	Yes	Yes	Yes
Tableau (118)	Yes	Yes	Yes
Qlik Sense (40)	Yes	Yes	Yes

4.1.9. Extendibility of Custom Data Connectors

Power BI, Tableau, and Qlik Sense support using and developing custom data connectors for their tools within the limitations. Power BI has detailed documentation and tutorials available at the developer's disposal and multiple scenario-based examples in their official GitHub repository. Tableau also provides an SDK, but it has limited support on ODBC and JDBC types.

Table 10. Comparison of custom data connector SDKs of data analytics tools

Platform	SDK Name	Documentation	Samples
Power BI (62)	Power Query SDK[1]	Available	Official repo on GitHub[2]
Tableau (79)	Tableau Connector SDK	Available	Official repo on GitHub[3]
Qlik Sense (42)	QVX SDK	Available	Limited in SDK files

4.1.10. Extendibility of Custom Data Visualizations

Power BI, Tableau, and Qlik Sense support using and custom visualization for their tools. Developers can create custom visualizations in Tableau as dashboard extensions and Qlik as custom visualization objects. Visualization extensions can be integrated with other systems and visual libraries, and it can all be done using open standards and front-end technologies such as HTML, CSS, and JS.

Table 11. Comparison of custom visualization SDKs of data analytics tools

Platform	SDK Name	Documentation
Power BI (119)	Power BI Visual Tools (pbiviz)[4]	Available
Tableau (80)	Extensions API SDK[5]	Available
Qlik Sense (43)	QVX SDK	Available

---

[1] https://aka.ms/powerquerysdk
[2] https://github.com/microsoft/DataConnectors
[3] https://github.com/tableau/connector-plugin-sdk
[4] https://github.com/microsoft/PowerBI-visuals-tools
[5] https://tableau.github.io/extensions-api/

4.1.11. Community, Learning, Support and Certification

Power BI has an active community forum (120) that allows any member to ask questions about visualization, data modeling, data cleaning, calculation, and integration with other services. Alongside the clean documentation, Microsoft also offers free learning paths for every skill level with gamification features (121).

Tableau offers free how-to videos for new beginners and role-based, instructor-led learning paid paths (122). Tableau community is one of the most active communities on social media with visual challenges, hashtags, and collaboration. Public dashboards also have a *"Hire me"* button that simplifies the hiring process for developers.

Qlik has *"Continuous Classroom"* (123), offering free and subscription required training alongside instructor-led training and role-based packages. Qlik community has a forum (124) for questions where they also promote events and new features.

In 2019, Power BI contributors aligned with Tableau contributors under *"Workout Wednesday"* (125), to create a weekly challenge every Wednesday, previously only for Tableau, now for each platform.

Microsoft (126) has six, and Tableau (127) has five paid exams for different levels of user certification listed in Table 12.

Table 12. Available certificates for data analytics tools

Platform	Certificate Name
Microsoft	Power Platform App Maker Associate, Exam PL-100
	Power Platform Functional Consultant Associate, Exam PL-200
	Power BI Data Analyst Associate, Exam PL-300
	Azure Enterprise Data Analyst Associate, Exam DP-500
	Power Platform Solution Architect Expert, Exam PL-600
	MCSA: BI Reporting, Exam 70-778, 70-779
Tableau	Tableau Desktop Specialist
	Tableau Certified Data Analyst
	Tableau Exam Readiness Courses
	Tableau Server Certified Associate
	Tableau Certified Associate Consultant
	Tableau Certified Associate Architect

4.2. Case Study Introduction

NMQ Digital is a global provider of digital marketing execution services. It is a privately held Dutch company with branches in Amsterdam (NLD), Istanbul (TUR), Lisbon (PRT), Kuala Lumpur (MYS), and Portland (USA). At its core, it can be described as a pool of skilled professionals who have expertise in many digital domains such as end-to-end digital operations, content and performance marketing, software development, business intelligence, and more.

NMQ Digital's business intelligence experts provide advice, design projects, support migrations or implementations, and maintenance services at a scale for global companies and internally. Due to the nature of the consultancy business, it is expected that experts have broad knowledge in the domain, expertise in execution, maintenance, and delivery. Therefore, experts usually get exposed to a vast of BI tools and solutions, data sources, data strategies or lack of them, and different levels of expectations.

This thesis addresses an internal challenge as the case study, which impacts NMQ Digital's capacity and delivery optimization. NMQ Digital uses Adobe Captivate Prime as their primary LMS solution besides the customer-provided content, BambooHR as HR management solution, and an internal database for demands and requests. The main goal is to develop an analytics project to search, analyze, and match skills and demands to utilize the resources, and this goal requires integration between these systems.

Power BI is already bundled with the company's other Microsoft Office365 license and is internally in use by different business units. Power BI successfully connects BambooHR's reports through exported datasheets and an internal database, but due to limitations on Adobe Captivate LMS, it was not successful to merge those sources effectively to provide a solution. Officially supplied integration solutions by Adobe Captivate LMS are limited on data sets and require additional services, IT knowledge, and effort to keep it running.

This thesis searches alternative ways and tries to provide a solution to import data through APIs with a custom data connector development to seamlessly integrate to Power BI, allowing end-users to connect easily without any technical knowledge besides the credentials.

4.3. Analysis of Adobe Captivate Prime as Data Source

4.3.1. Officially Supported Available Connectors

4.3.1.1. Captivate Prime FTP Connector & Custom FTP Connector

The integration administrator can integrate Captivate Prime with arbitrary external systems to automate data synchronization using the FTP Connector to import internal users, import xAPI, export user skills, and export learner transcripts. Captivate Prime also provides a Custom FTP connector to connect a custom FTP location as the same actions with Captivate Prime FTP Connector. Only one Captivate Prime FTP account can be created for a given Captivate Prime account.

4.3.1.2. Power BI Connector

The integration administrator can set up the Power BI workspace to be incrementally populated with two live data sets - learner transcript and user skill reports.

4.3.2. Need for a Custom Data Connector

Setting up the Custom FTP involves a lead time and requires IT support to allow the list of IPs and ports also create certain folders with specific permissions on the external FTP servers. Also, it is only allowed to be configured with SFTP servers.

In addition to these limitations, the *"Transform Load"* option for the live data sets, and relations or interactions with other sources are not available.

Therefore, having a custom data connector helps the integration administrator to get the desired data sets into Power BI with the help of the APIs.

Figure 9 Power BI Service Live Connection error prompt

44
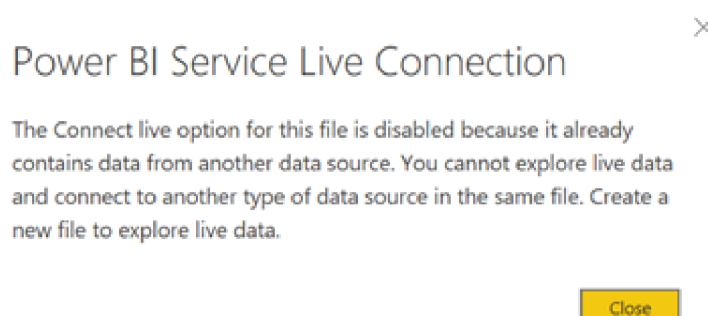
4.3.3. Overview of API Usage

As a first step, the integration admin is required to register the application using the Integration Admin App to make API calls. OAuth 2.0 is the framework to authenticate and authorize the client applications. An access token is valid for seven days. After the expiration, the integration admin must generate a new access token using the refresh token. The existing token is returned if a new access token is generated from the refresh token while valid. (97)

The API call can be made by making an HTTP request. The *"GET, PUT, POST, DELETE, and PATCH"* methods are available depending on the endpoint. For some requests, pre-defined query parameters can also be passed (97). Only the *"GET"* method will be included in the development since a data connector only aims to import data, not update or create.

After making a successful API call, the client obtains a JSON document according to the JSON API specification. The response also contains an HTTP status code which helps verify and perform the appropriate next steps in the application logic. The server sends an error response when an API call fails.

An API call may result in a long list of objects to be returned in the response; therefore, the pagination attribute enables fetching the results sequentially in terms of multiple pages, where each page contains a range of records.

4.3.4. Target Tables and Selected Edges

"Badges, Users, UserGroups, Catalogs, Skills, and LearningObjects" tables can be collated from the edges respectively; *"badges, users, usergroups, catalogs, skills, and learningobjects"* without any parameters. Other edges may require additional parameters to make an API request to collate a table. For example, to create a table named *"UserBadges"* with individual badges, *"id"* values from the *"Users"* table must be passed as a parameter for each user and, therefore, for each request. To support individual record-based queries, *"getUserBadges"* and *"getUserEnrollments"* functions are also included for invoking.

4.4. Development

Microsoft Visual Studio with Power Query SDK extension is essential to develop a custom data connector for Power BI. The following part covers program and extension installations, program design, flowcharts, and handling essential aspects in development.

4.4.1. Power BI Desktop Installation

Microsoft Power BI Desktop can be installed as an app from Microsoft Store or as a single executable containing all supported languages. Both approaches get the latest version; however, some differences are worth noting. Microsoft Store handles automatic updates, downloads only components that have changed in each update, does not require admin privileges, and automatically detects language (128). Appendix C lists the minimum requirements to run Power BI Desktop.

Figure 10 Home Page of Power BI Desktop
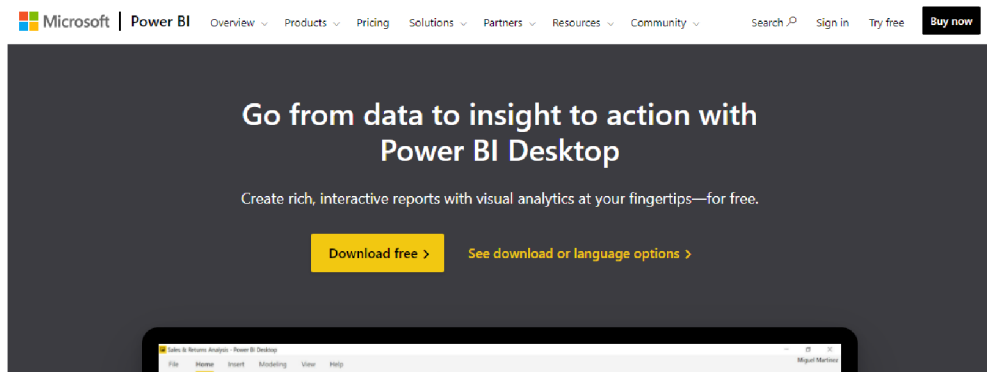
Source: (48)

4.4.1.1. Install as an app from Microsoft Store

To install Power BI Desktop as an app, click the *"Download free"* button on the Power BI website[1] (Figure 10), which prompts to open Microsoft Store[2], or open the *"Microsoft Store"* app in Windows OS and type *"Power BI Desktop"* to the search bar. Click on the target app where the search bar lists results, then click *"Get"* on the Power BI Desktop app page to install it to the system.

---

[1] https://powerbi.microsoft.com/en-us/desktop/
[2] https://aka.ms/pbidesktopstore

Figure 11 Power BI Desktop app on Microsoft Store
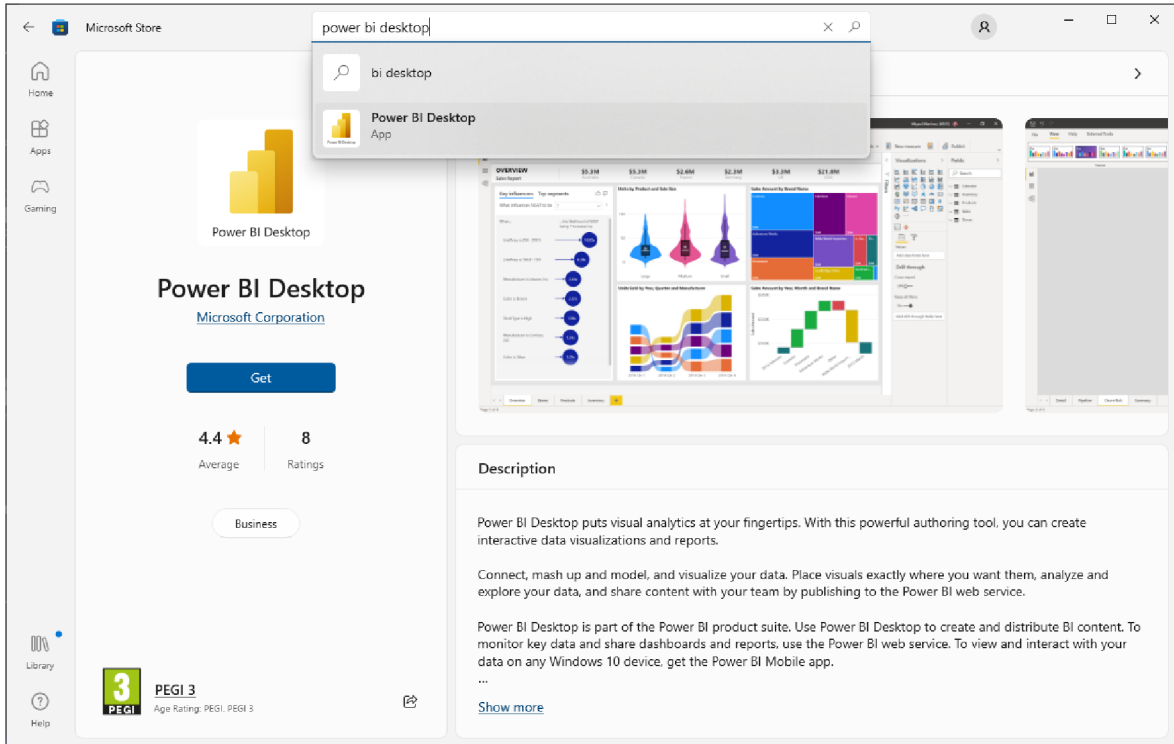
4.4.1.2. Install from a downloaded single executable file

To install Power BI Desktop from a downloaded single executable, click the *"See download or language options"* link (Figure 10) on the Power BI website[1], forwarding to the Microsoft Download Center page[2]. Select a language (Figure 12) and CPU architecture (Figure 13), then click *"Next"* to start downloading the file: *"PBIDesktopSetup_x64.exe"*. Double click on the downloaded file to run the installer and complete the setup steps.

Figure 12 Selecting a language for Power BI Desktop
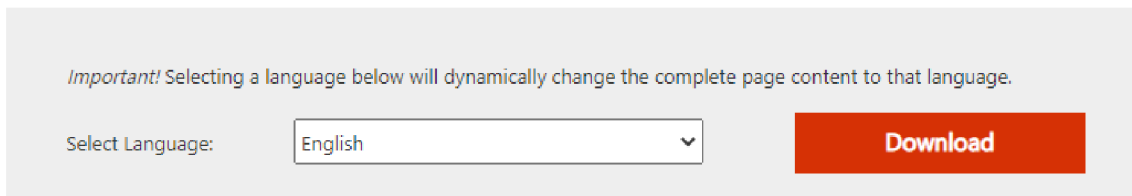
Source: (129)

Figure 13 Selecting CPU architecture for Power BI Desktop
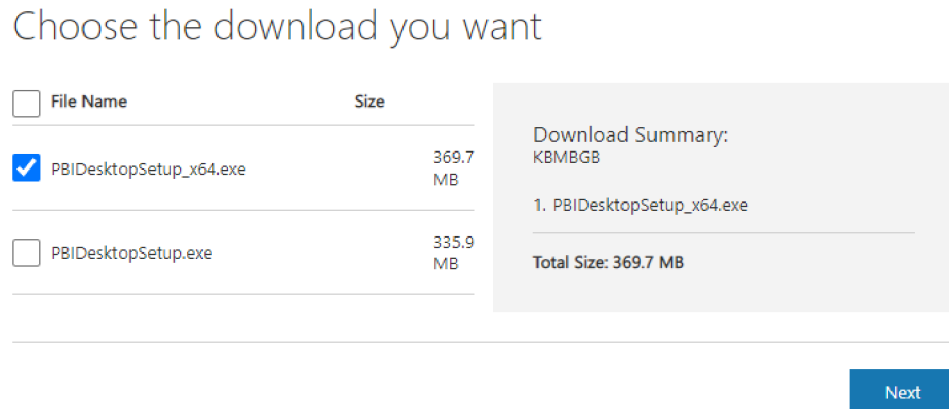
Figure 14 Welcome screen of Power BI Desktop
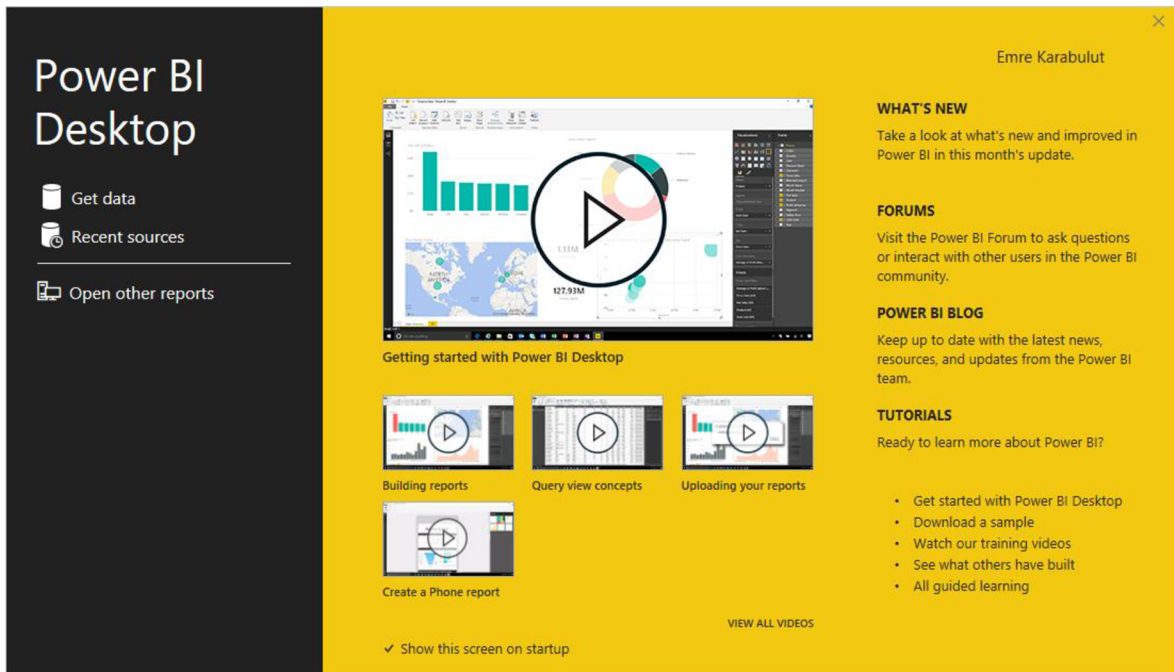
4.4.2. Development Environment Setup

The development environment for Power BI applications requires installing the Power Query SDK, which provides an M language service for Visual Studio and a framework for building Data Connectors for Power BI. The Power Query SDK version 1.0.0.25 works with Visual Studio 2019 (130). Due to this dependency, Visual Studio 2019 will be used as the selected IDE instead of Visual Studio 2022, which is the latest release as of today (131). Following devices with detailed specifications (Table 13) are used for development and reproduce the results as a proof of concept with a fresh installation.

Table 13. Development Devices Specifications

	Device for Development	Device for Proof of Concept
Device ID	Lenovo V510-14IKB	Intel® NUC Kit NUC5i7RYH
Processor	Intel Core i5-7200U	Intel Core i7-5557U
Cores / Threads	2 / 4	2 / 4
Processor Base Frequency	2.50 to 2.70 GHz	3.10 to 3.40 GHz
Memory Size	20 Gb	16 Gb
Memory Type	DDR4-2133 MHz	DDR3L-1600 MHz
Operating System	Windows 10 Pro for Workstations	Windows 10 Pro
System Type	64-bit OS, x64-based processor	64-bit OS, x64-based processor

4.4.2.1. Microsoft Visual Studio Installation

To install Visual Studio 2019 Community edition, scroll down the downloads page[1] and click *"Older Downloads"* link[2]. Navigate to *"Still want an older version?"* section, click *"2019."* On the opened accordion tab, navigate to *"Visual Studio 2019 and other Products"* and click *"Download."* Appendix D lists the system requirements to run Visual Studio 2019 (132).

Figure 15 Welcome screen of Visual Studio 2019

---

[1] https://visualstudio.microsoft.com/downloads/
[2] https://visualstudio.microsoft.com/vs/older-downloads/
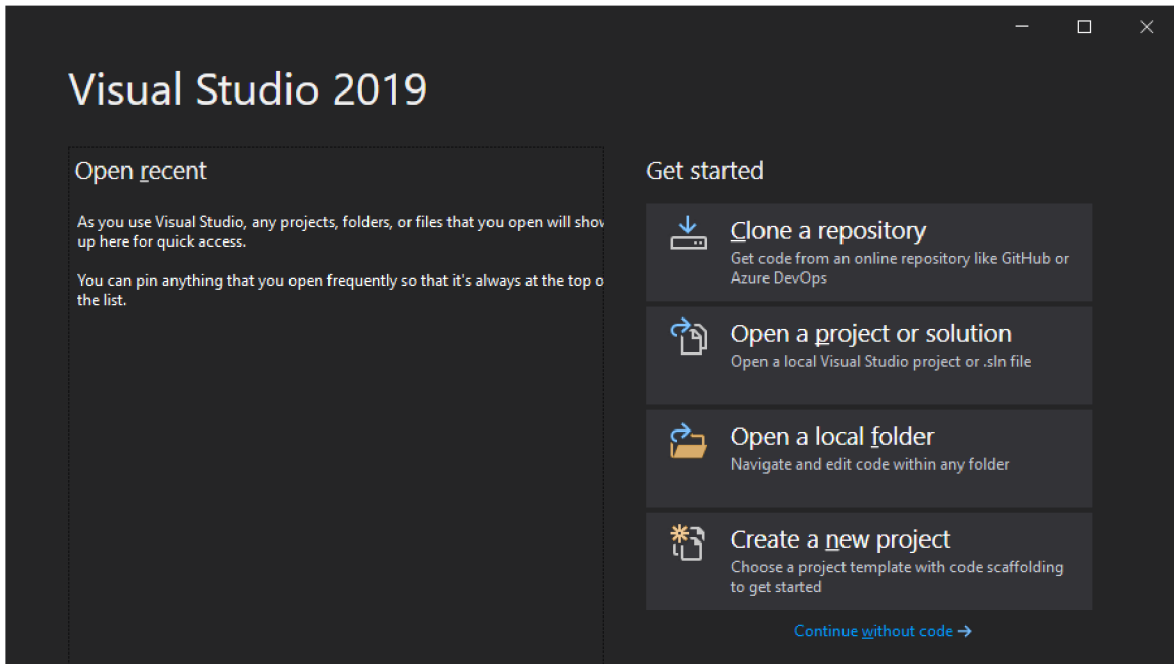
4.4.2.2. Power Query SDK Installation

To install Power Query SDK, navigate to the download page on Visual Studio Marketplace[1]. Click *"Download"* and wait for downloading file *"PowerQuerySDK.vsix"* completely. Double click on the downloaded file to run the installer and follow the instructions.

An alternative installation is possible via the Extension Manager in Visual Studio. Navigate to *"Extensions > Manage Extension,"* then (Figure 16) type *"Power Query SDK"* into the search bar. Results will be listed by relevance; hence, *"Power Query SDK"* is expected to be the first result. After clicking *"Download"* on the desired extension, changes will be scheduled and begin when all Visual Studio windows are closed.

Figure 16 Search results in Manage Extensions window in Visual Studio 2019
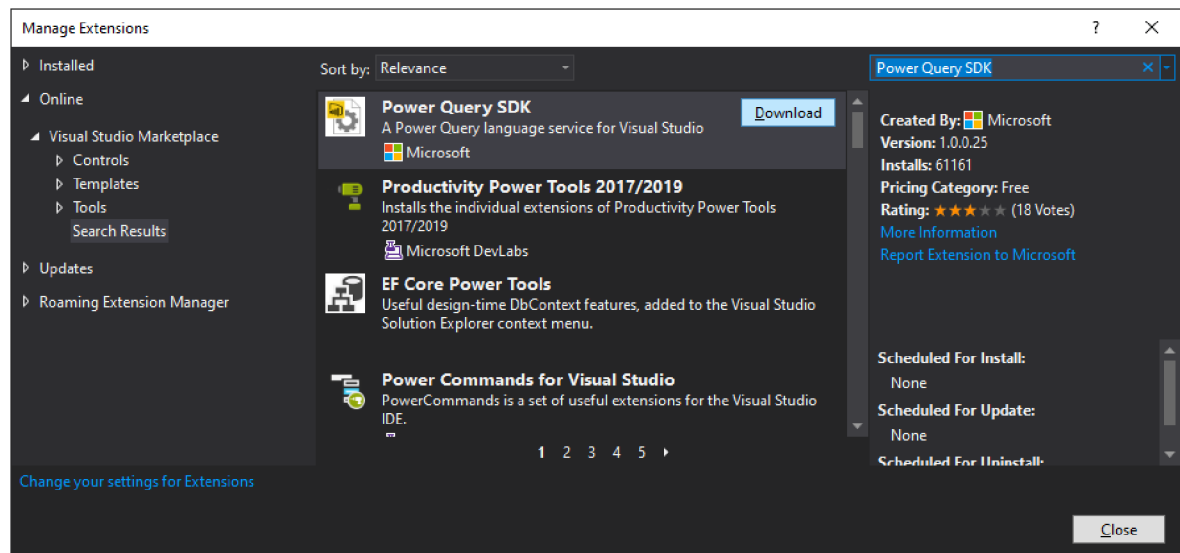
4.4.2.3. Creating a New Data Connector Project

To create a new Data Connector project in Visual Studio, select *"Create a new project"* in the welcome screen (Figure 15). Type *"Data Connector"* into the search bar, then select *"Data Connector Project"* in the results and click *"Next"* (Figure 17). On the following screen (Figure 18), set the project name, *"AdobeCaptivatePrime"* in this case, the project location, and the project solution name. Clicking the *"Create"* button generates a new project containing the template files explained in Table 14.

---

[1] https://aka.ms/powerquerysdk

Figure 17 Creating a new project in Visual Studio 2019
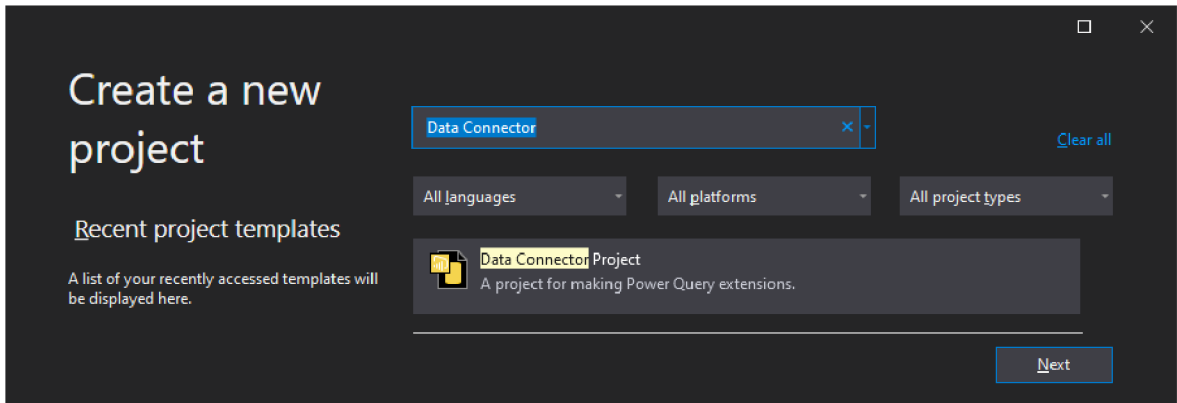
Figure 18 Setting details of the new data connector project in Visual Studio 2019
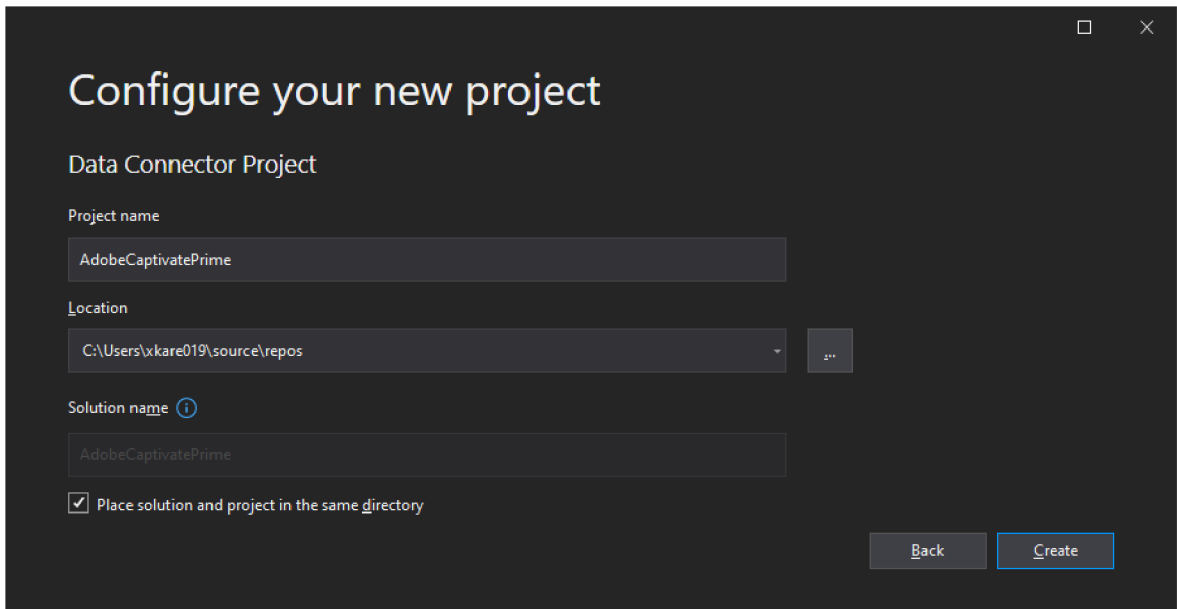
Table 14. Descriptions of default template files of a new data connector project

File Name	Description
<connectorName>.sln	A project file for Visual Studio
<connectorName>.mproj	A project template
<connectorName>.pq	A connector definition file
<connectorName>.query.pq	A query test file
Resources.resx	A string resource file
<connectorName>{16,20,24,32,40,48,46,80}.png	A set of image files to create icons

4.4.2.4. Building in Visual Studio 2019

Building a data connector project produces a .mez file. There is no auto-deploy function supported natively, but it can be installed as an extension to move *"<connectorName>.mez"* file to *"[Documents]\Microsoft Power BI Desktop\Custom Connectors"* directory.

4.4.2.5. Testing in Visual Studio 2019

The Power Query SDK provides basic query execution capabilities allowing to test the extension (Figure 19) without switching over to Power BI Desktop. Each new data connector project generates a default *"<connectorName>.query.pq"* file to run test queries within Visual Studio without having to register the .pqx file to Power BI Desktop.

Figure 19 An empty M Query Output window in Visual Studio 2019
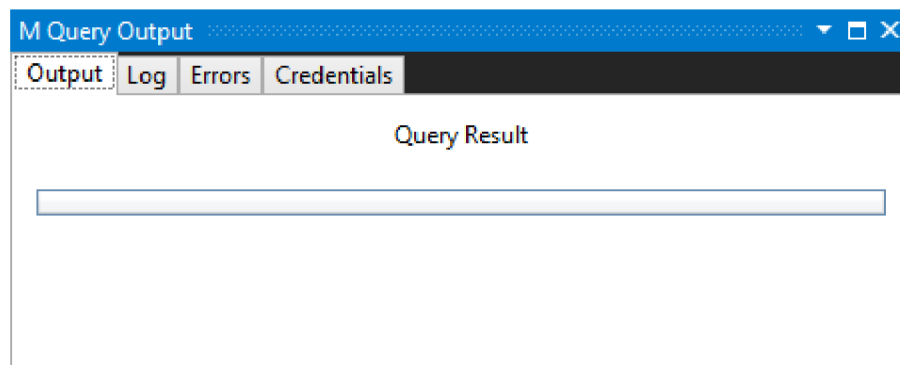
4.4.3. Flowchart Diagram

A graphical representation of the basic algorithm is represented in Figure 20, which roughly overviews the process. The flowchart diagram of the final algorithm is represented in detail in Appendix H.

Figure 20 Flowchart diagram of the algorithm overview

4.4.4. Required M Functions

List of required functions briefly explained in Table 15. The official Power Query M Documentation on Microsoft Docs lists each function's extended explanation and syntax.

Table 15. Required M functions and descriptions

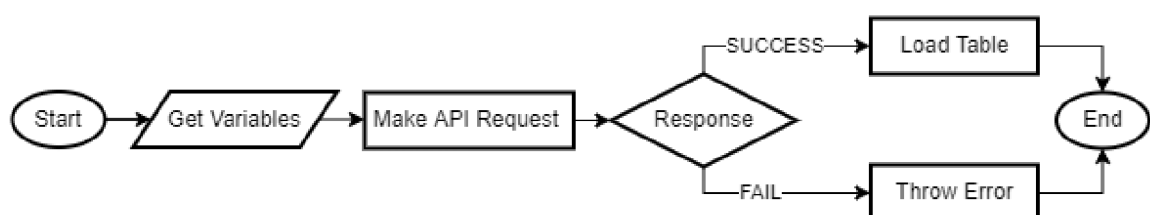| Function	Description
Json.Document	Returns the contents downloaded from the URL as binary.
List.Generate	Generates a list of values given four functions that generate the initial value, test against a condition, and, if successful, select the result and generate the next value with an optional selector.
Record.FieldNames	Returns the names of the fields in the record as text.
Splitter.SplitByNothing	Returns a function that does no splitting, returning its argument as a single element list.
Table.ExpandRecordColumn	Given the column of records in the input table, creates a table with a column for each field in the record.
Table.FromList	Converts a list into a table by applying the optional splitting function to each item in the list.
Table.FromRows	Creates a table from the list rows where each element of the list is an inner list that contains the column values for a single row.
Table.FromValue	Creates a table with a column containing the provided value or list of values.
Table.HasColumns	Indicates whether the table contains the specified column(s).
Table.ToList	Converts a table into a list by applying the specified combining function to each row of values in the table.
Type.AddTableKey	Adds a key to the given table type.
Value.Metadata	Returns a record containing the input's metadata.
Value.ReplaceType	Replaces the input's type information.
Value.Type	Returns the type of the given value.
Web.Contents	Returns the content of the JSON document.

4.4.5. Certification Requirements

Certifying a Power Query custom connector makes the connector available publicly, out-of-box, within Power BI Desktop. Certified connectors are supported in PowerBI.com and all versions of Power BI Premium, except dataflows (133). Microsoft has a certain set of requirements for certification for artifacts, features, and style. This thesis follows the practices required for certification.

53

4.4.6. Developing the program

4.4.6.1. Versioning

Versioning is not supported currently in Power Query (134). Microsoft recommends all connector developers to use it once available, but it is required only for certified connectors. It can be included with a simple metadata record above the section document (Appendix J). It should follow the semantics of major, minor, and patch, respectively.

4.4.6.2. Icons

According to certification requirements, a custom connector should have icons. A data connector template provides a default icon set (Figure 21), which should be updated with an original icon set that best represents the data source (Figure 22).

"AdobeCaptivatePrime.Icons" generated (Appendix J, lines between #87 and #100) by data connector template to define icon set for the extension.

Figure 21 Default icon set generated by data connector template

Figure 22 New icon set for Adobe Captivate Prime Data Connector

4.4.6.3. String Resources

According to certification requirements, a custom connector should have its strings placed in (Figure 23) a *"resources.resx"* file. URLs and values should be hardcoded in the connector code and excluded in the resource file.

Figure 23 Resource file for Adobe Captivate Prime Data Connector
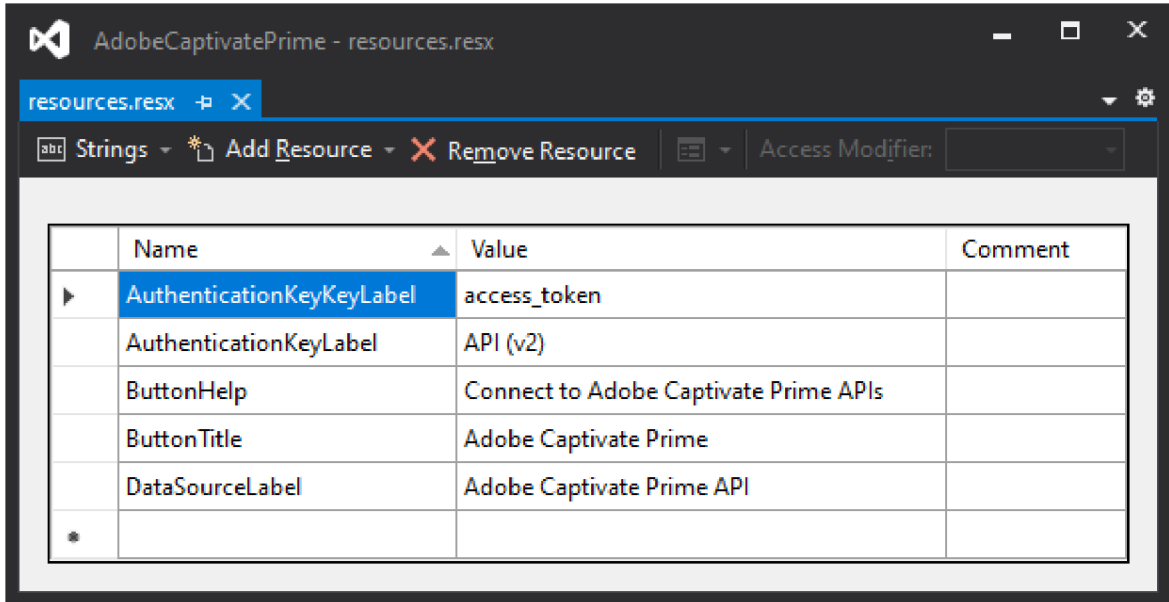
4.4.6.4. Handling Data Access

Functions marked as *"shared"* in the extension can be associated with a specific data source by including a *"DataSource.Kind"* metadata record on the function with the name of a *"Data Source"* definition record (Appendix J, line #4). Power BI asks for any required parameters for functions that may require running (Figure 24).

Figure 24 Requesting required parameter for Adobe Captivate Prime Data Connector
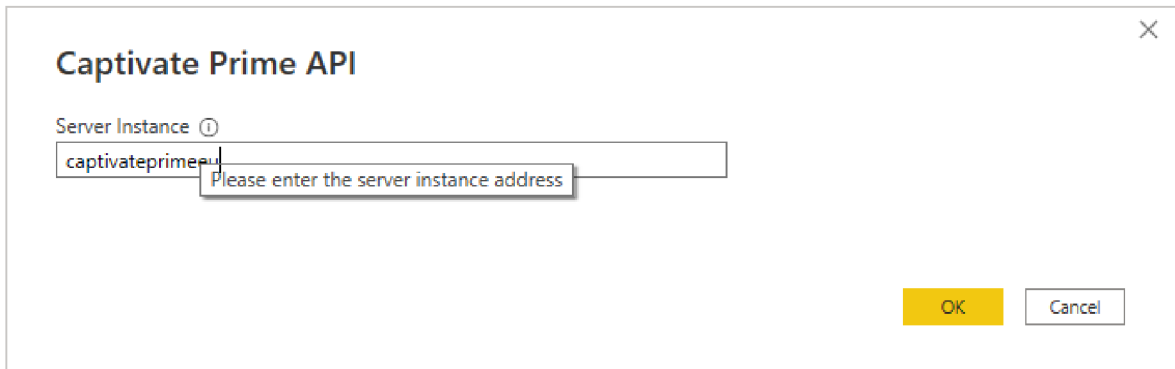
4.4.6.5. Handling Authentication

The *"Data Source"* record defines the authentication types supported by the data source and basic branding information like the display name and label. The name of the record becomes a unique identifier.

An extension can support one or more kinds of authentication of *"Implicit, OAuth, Aad, UsernamePassword, Windows, and Key."* Each kind is a different type of credential, and the type of credential drives the UI displayed to end-users in Power BI.

Although Adobe Captivate Prime API uses OAuth 2.0 authentication framework, which requires additional flow and steps for authentication explained in Figure 2. Bearer tokens are the predominant access token used with OAuth 2.0, simply an opaque string (13). This thesis uses the Key kind of authentication (Figure 25) for Bearer token usage with a manually generated *"access_token"* string.

Figure 25 Credential prompt of Adobe Captivate Prime Data Connector
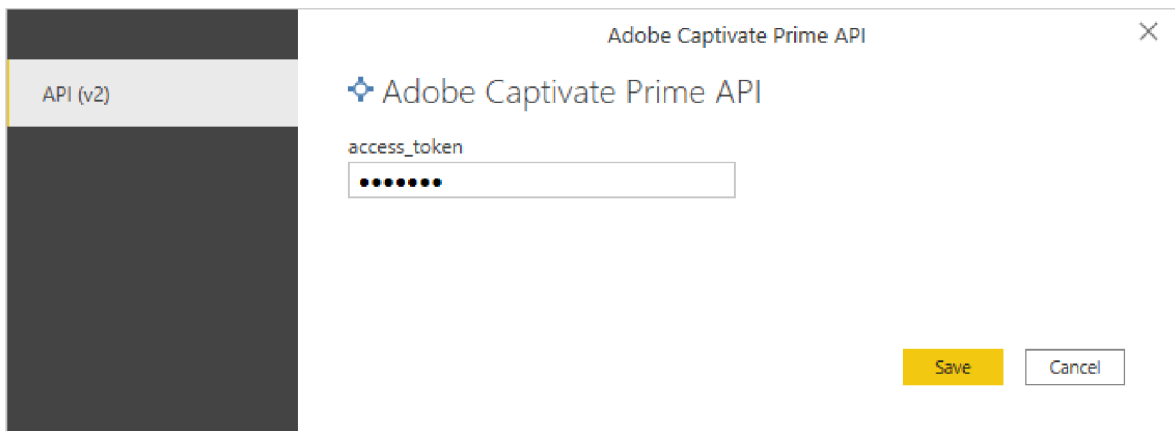
4.4.6.6. Handling Status Codes

The *"Web.Contents"* function has built-in functionality for dealing with specific HTTP status codes. It automatically retries requests that fail with one of the following status codes: 408, 429, 503, 504, and 509. In the event of a credential exception with a 401 or 403 status code, it causes an authentication prompt to ask for credentials. It follows redirections of any of the following status codes: 300, 301, 302, 303, and 307. *"ManualStatusHandling"* helps to override the default behavior in the extension.

4.4.6.7. Publishing to UI

The publish method (Appendix J, lines between #78 and #85) provides the Power Query UI with the information it needs to expose this extension in the *"Get Data"* dialog.

Figure 26 Adobe Captivate Prime (Beta) listed under Online Services in Get Data
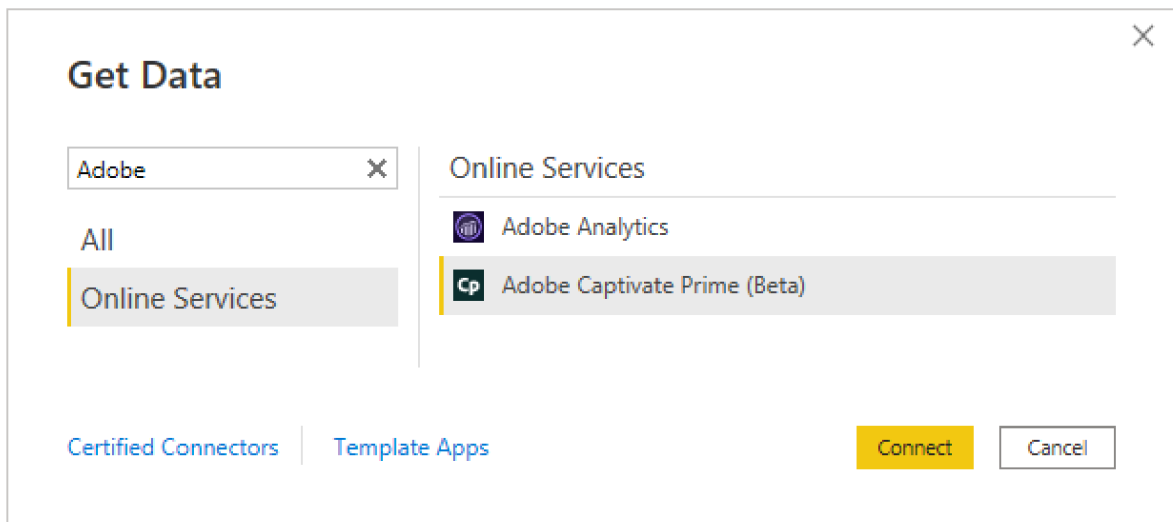
4.4.6.8. Handling Navigation

Navigation tables are a core part of providing a user-friendly experience for the data connector. Table type metadata is needed for the extension to return a table value that Power Query can recognize as a *"Navigation Tree."*

"Table.ToNavigationTable" function (Appendix J, lines between #130 and #151) adds the required table type metadata to create a navigation table (Figure 27) with a predefined object table (Appendix J, lines between #27 and #37).

Figure 27 Flat navigation tree listed under server instance in Navigator
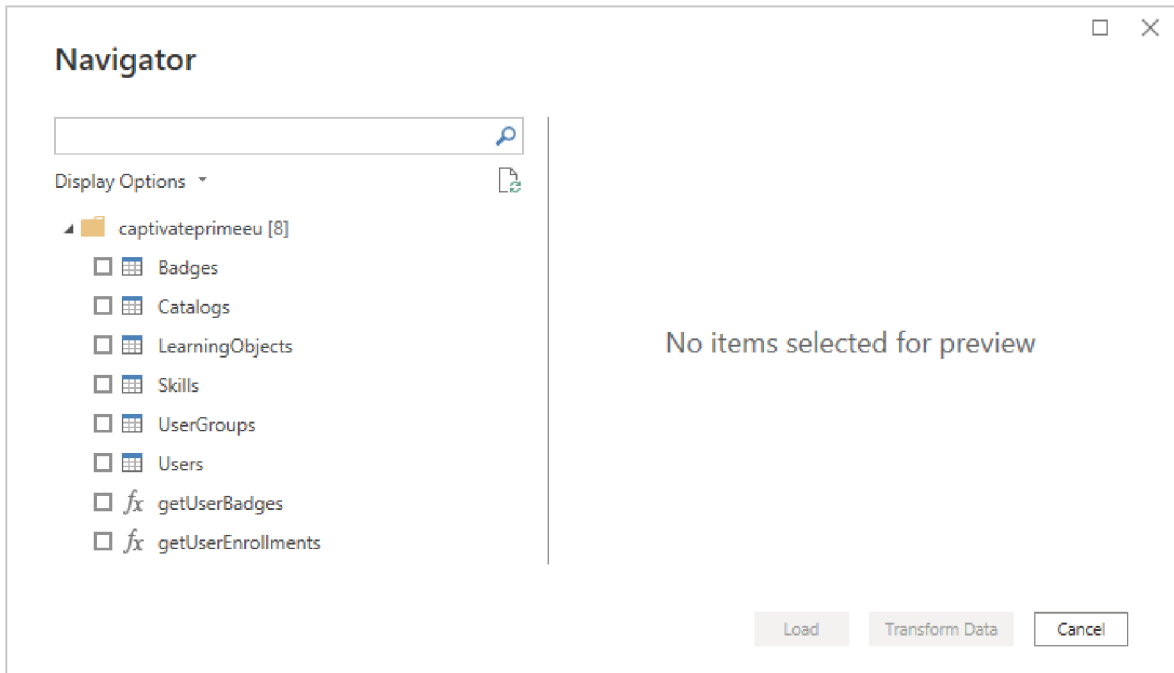
4.4.6.9. Handling Pagination

Adobe Captivate Prime API has a mechanism to transmit large volumes of records broken up into pages of results. API response has the *"next"* value in the JSON records representing the next batch of the result. Power Query has the flexibility to support many different paging mechanisms. *"Table.GenerateByPage"* is mainly responsible for the paginated request (Appendix J, lines between #153 and #169) and uses *"List.Generate"* function, which makes API calls until the *"next"* value returns *"null"* and collates all pages into a single table.

4.4.6.10. Handling Transformations
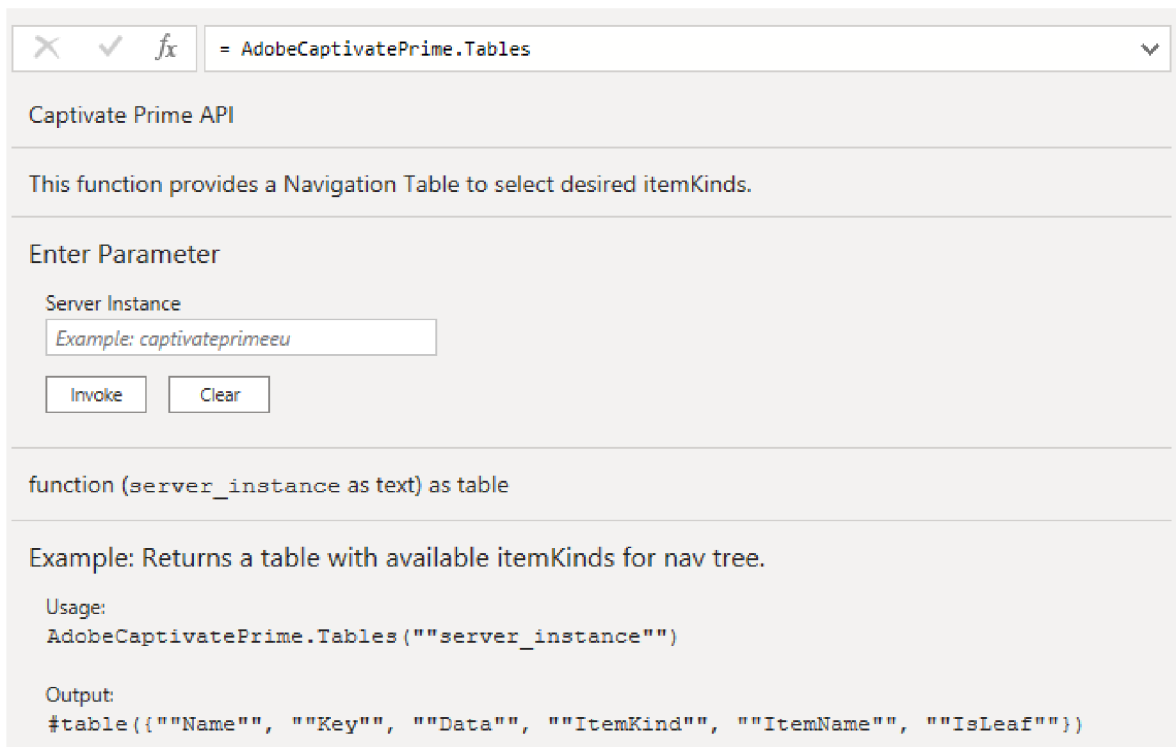
The data source consistently presents the response data: column names, data types, and hierarchical structure are consistent for a given endpoint. Therefore, it is appropriate to apply the same set of transformations to get the data in a format acceptable to Power BI. *"ExpandAttributes"* function (Appendix J, lines between #122 and #128) performs static transformations for the semi-structured JSON responses to get actual data and expand records into values.

4.4.6.11. Handling Documentation

According to certification requirements, a custom connector must provide function documentation metadata. Although Power Query automatically generates an invocation UI based on the function's arguments, functions with documentation typically provide a better user experience with descriptions, tooltips, and even sample values.

An example output of function documentation codes (Appendix J, lines between #10 and #14) and parameter documentation codes (Appendix J, lines between #16 and #21) is shown in Figure 28.

Figure 28 Function documentation in Power Query Editor

4.4.7. Code

The developed custom data connector, Adobe Captivate API (Beta), successfully performs data import from a third-party system through Captivate Prime APIs. Previous sections cover some of the functions and partially explain the code blocks. The full version of the final code is provided in Appendix J. It is also available as a public repository in the authors' GitHub account[1] under the GPL-3.0 License.

Figure 29 Example of successful data import process in Power BI

---

[1] https://github.com/karabulute/powerbi-dataconnector-adobecaptivateprime
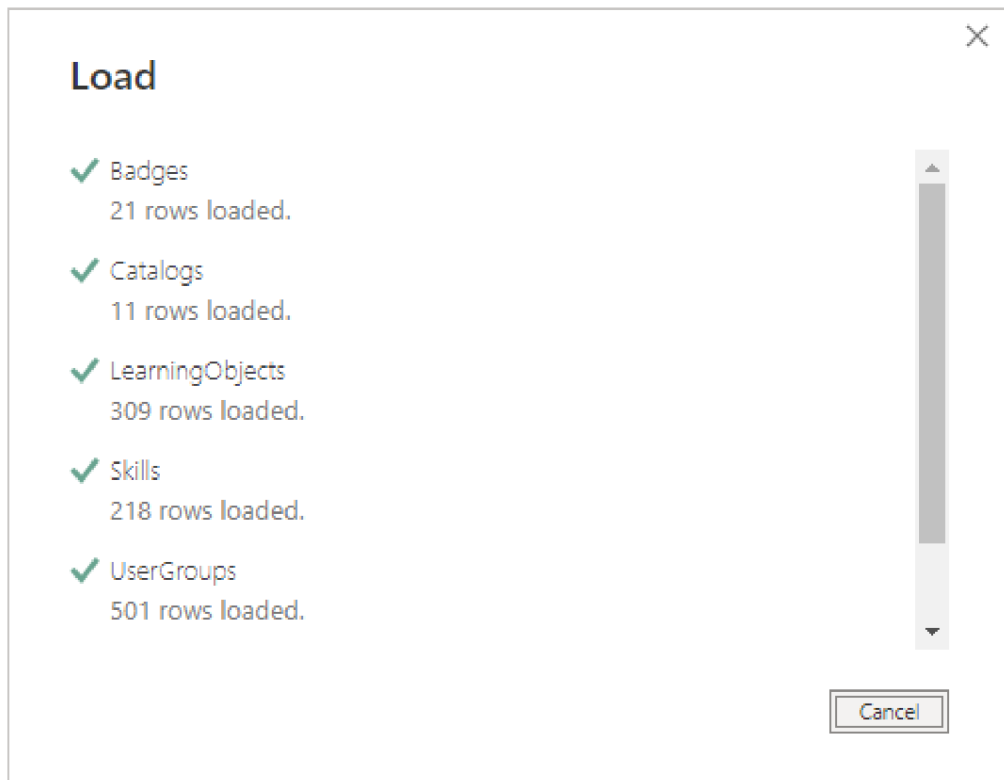
5. Results and Discussions

5.1. End-Product as a Custom Data Connector

After placing the built extension file, *"AdobeCaptivatePrime.mez,"* under the custom connectors folder to serve as a data connector, it can be tested in Power BI through the *"Get Data"* function (Figure 26). By default, Power BI only allows Microsoft certified and other trusted third-party extensions to load; therefore, security settings should be updated. Power BI allows any extension to load without validation or warning with the settings under *"Security > Data Extensions"* (Appendix E). Once re-started to reflect changes, Power BI prompts end-users for uncertified (Appendix F) and beta-staged (Appendix G) custom data connectors.

Adobe Captivate Prime data connector requires a valid server instance to make API calls (Figure 24) and *"access_token"* value (Figure 25) for Bearer type authentication. Within its capabilities (Table 16), it displays the "Navigator" interface to select tables and functions available and then loads (Figure 29) it to Power BI.

Importing data and loading tables with a custom data connector eliminates the limitation of *"DirectQuery/LiveConnect"* and enables adding more data sources and tables to be connected, edited, mixed, and transformed.

Table 16. Adobe Captivate Prime data connector table capabilities

Tables	Description	Notes
Badges	Retrieves a list of badges	As table
Catalog	Retrieves a list of catalogs	As table
LearningObjects	Retrieves the details of learning objects	As table
Skills	Retrieves a list of skills	As table
UserGroups	Retrieves a list of User Groups	As table
Users	Retrieves the list of users	As table
UserBadges	Retrieves list of users' badges	Requires function invoke on Users[id]
UserEnrollments	Retrieves a list of users' enrollments	Requires function invoke on Users[id]

5.2. Further Discussion

In its current state, the final version of the data connector can be used on the Power BI desktop, as demonstrated. Adding a *"TestConnection"* allows it to be used in on-premises data gateways to refresh the data.

Developing and publishing a template app in the Power BI Apps marketplace provides end-users a prebuilt report connected to data and can be used.

Certified connectors are bundled out-of-box in Power BI Desktop. Having certification eliminates the requirements (Appendix E, Appendix F) of custom data connectors usage. Microsoft's connector certification program governs Power Query extensions certification. Meeting the prerequisites and requirements of the certification is required for registration. For this purpose, the following actions can be taken into consideration:

- Developing an example Power BI Desktop file for testing connector
- Improving function documentation metadata
- Adding a *"TestConnection"* handler

Implementing unit testing early in the connector development process enables to follow the principles of test-driven development. Unit testing is accomplished in the context of Visual Studio's Power Query SDK, and it is a highly recommended best practice.

Adobe Captivate Prime authenticates through OAuth protocol, and Power BI better supports this type of credentials in data connector extensions. An *"access_token"* expires after seven days and should be refreshed manually in the current scope. Implementing an OAuth Flow allows custom logic for the service, such as initiation, exchanging tokens, and automatically refreshing *"access_token"* with *"refresh_token"* for an uninterrupted data refresh experience.

Captivate Prime APIs provide more endpoints for additional data to be imported. The capabilities of the Adobe Captivate Prime data connector can be extended by adding more functions to import additional data, such as user notifications, users' skills, and skill interests.

Considering the release of the Adobe Captivate Prime data connector either with or without certification, publishing external documentation helps end-users with its usage.

6. Conclusion

This research aimed to compare the capabilities and extendibility of modern-day data analytics tools. Based on the thorough literature review and non-experimental research method, it can be concluded that enterprises benefit from ABI tools in the core, but not all tools/platforms are created equal; and BI strategy, business needs, organization structure, technology stack in use, employees' technical knowledge, and most significantly the budget are vital factors to discuss while considering the selection of the platform.

By benchmarking various aspects of data analytics tools, this thesis has shown again that every platform aims to help end-users get the most of its data, and also every platform is built differently from licensing to deployment, capabilities to extendibility. The leading companies support their data analytics tools with additional services to augment throughout and enable users to compose low/no-code workflows and applications.

By introducing a real-life systems integration problem as a case study, this research tried to suggest an alternative way to overcome the integration limits, which is common in the domain and might be seen in the other third-party data sources' integration. Modern web APIs have shown that as a technology, it provides leverage for integrating data between platforms.

Furthermore, challenged by the development process, this thesis has demonstrated how to develop a custom data connector for the selected platform and suggested improvement points to make it publicly available through certification. This thesis has also highlighted the importance of community, documentation, software development kits, scenario-based samples, and the encouragement of the leading platforms for developers to contribute to the platform's development. As the outcome of the development process, a custom data connector has solved the case study problem, and it has been released publicly for community usage; hence, it has completed the additional goal of this thesis.

Based on these conclusions, the author suggests a detailed preliminary analysis of the platforms, considering to extendibility to select the right BI solution while meeting the BI strategy requirements within the limitations.

7. References

1. **Huylebrouck, Dirk.** *Africa and Mathematics: Mathematics, Culture, and the Arts.* Cham : Springer, 2019. 978-3-030-04036-9.

2. **The National Aeronautics and Space Administration.** *NASA Systems Engineering Handbook.* s.l. : 12th Media Services, 2017. 978-1-680-92089-5.

3. **Liu, Dahai.** *Systems Engineering Design Principles and Models.* s.l. : CRC Press, 2015. p. 4. 978-1-48-228246-7.

4. **The International Council on Systems Engineering.** Systems Engineering Definition. *International Council on Systems Engineering Website.* [Online] [Cited: February 10, 2022.] https://www.incose.org/about-systems-engineering/system-and-se-definition/systems-engineering-definition.

5. —. *INCOSE Systems Engineering Handbook.* s.l. : John Wiley & Sons Inc, 2015. 978-1-118-99940-0.

6. **Langford, Gary O.** *Engineering Systems Integration: Theory, Metrics, and Methods.* Boca Raton : CRC Press, 2012. 978-1-4398-5288-0.

7. **INCOSE.** Systems Integration. *International Council on Systems Engineering Website.* [Online] 2015. [Cited: February 10, 2022.] https://www.incose.org/docs/default-source/TWG-Documents/002-systems-integration-and-se-pamphlet.pdf.

8. **The Naval Systems Engineering Steering Group.** *Naval Systems Engineering Guide.* s.l. : US Department of the Navy, 2004.

9. **Network Working Group.** RFC 1945 - Hypertext Transfer Protocol -- HTTP/1.0. *IETF Datatracker.* [Online] May 1996. [Cited: March 18, 2022.] https://datatracker.ietf.org/doc/html/rfc1945.

10. **Mozilla.** An overview of HTTP - HTTP. *MDN.* [Online] December 4, 2021. [Cited: March 18, 2022.] https://developer.mozilla.org/en-US/docs/Web/HTTP/Overview.

11. **Internet Engineering Task Force.** RFC 7617 - The 'Basic' HTTP Authentication Scheme. *IETF Datatracker.* [Online] September 2015. [Cited: March 19, 2022.] https://datatracker.ietf.org/doc/html/rfc7617.

12. —. RFC 6749 - The OAuth 2.0 Authorization Framework. *IETF Datatracker.* [Online] October 2012. [Cited: March 18, 2022.] https://datatracker.ietf.org/doc/html/rfc6749.

13. —. RFC 6750 - The OAuth 2.0 Authorization Framework: Bearer Token Usage. *IETF Datatracker.* [Online] October 2012. [Cited: March 18, 2022.] https://datatracker.ietf.org/doc/html/rfc6750.

14. **The Internet Society.** RFC 2616 - Hypertext Transfer Protocol -- HTTP/1.1. *IETF Datatracker.* [Online] June 1999. [Cited: March 18, 2022.] https://datatracker.ietf.org/doc/html/rfc2616.

15. **Internet Engineering Task Force.** RFC 7231 - Hypertext Transfer Protocol (HTTP/1.1): Semantics and Content. *IETF Datatracker.* [Online] June 2014. [Cited: March 18, 2022.] https://datatracker.ietf.org/doc/html/rfc7231.

16. —. RFC 7540 - Hypertext Transfer Protocol Version 2 (HTTP/2). *IETF Datatracker.* [Online] May 2015. [Cited: March 18, 2022.] https://datatracker.ietf.org/doc/html/rfc7540.

17. —. RFC 5789 - PATCH Method for HTTP. *IETF Datatracker.* [Online] March 2010. [Cited: March 19, 2022.] https://datatracker.ietf.org/doc/html/rfc5789.

18. **De, Brajesh.** *API Management: An Architect's Guide to Developing and Managing APIs for Your Organization.* Bangalore : Apress, 2017. 978-1-4842-1306-3.

19. **Red Hat.** What is an API? *Red Hat - We make open source technologies for the enterprise.* [Online] October 31, 2017. [Cited: March 16, 2022.] https://www.redhat.com/en/topics/api/what-are-application-programming-interfaces.

20. **IBM Cloud Education.** What is an Application Programming Interface (API). *IBM.* [Online] August 19, 2020. [Cited: March 15, 2022.] https://www.ibm.com/cloud/learn/api.

21. **Amazon.** What is an API? - API Beginner's Guide - AWS. *Cloud Computing Services - Amazon Web Services (AWS).* [Online] 2022. [Cited: March 16, 2022.] https://aws.amazon.com/what-is/api/.

22. **Box, Don.** A Brief History of SOAP. *XML.com.* [Online] April 4, 2001. [Cited: February 12, 2022.] https://www.xml.com/pub/a/ws/2001/04/04/soap.html.

23. **Jin, Brenda, Sahni, Saurabh and Shevat Amir.** *Designing Web APIs: Building APIs That Developers Love.* Boston : O"Reilly, 2018. 978-1-492-02692-1.

24. *Measuring the Success of Changes to Existing Business Intelligence Solutions to Improve Business Intelligence Reporting.* **Dedić, Nedim and Stanier, Clare.** [ed.] A Min Tjoa, et al. Vienna : Springer, Cham, 2016. Vol. 10th International Conference on Research and Practical Issues of Enterprise Information Systems (CONFENIS), pp. 225-236. 978-3-319-49943-7.

25. **Tableau.** Business Intelligence: What It Is & Its Importance. *Business Intelligence and Analytics Software.* [Online] 2022. [Cited: January 10, 2022.] https://www.tableau.com/learn/articles/business-intelligence.

26. **Microsoft.** What Is Business Intelligence. *Microsoft Power BI.* [Online] 2022. [Cited: Jan 15, 2022.] https://powerbi.microsoft.com/en-us/what-is-business-intelligence/.

27. **Erl, Thomas, Khattak, Wajid and Buhler, Paul.** *Big Data Fundamentals: Concepts. Drivers & Techniques.* Crawfordsville : ServiceTech Press, 2016. pp. 6-12. 978-0-13-429107-9.

28. **Google.** Unified Advertising and Analytics. *Google Marketing Platform .* [Online] [Cited: March 3, 2022.] https://marketingplatform.google.com/about/.

29. **Muret, Paul.** Introducing the Google Analytics 360 suite. *The Keyword | Google.* [Online] March 15, 2016. [Cited: March 18, 2022.] https://www.blog.google/products/marketingplatform/360/introducing-google-analytics-360-suite/.

30. **Google.** Overview. *Google Data Studio.* [Online] [Cited: March 5, 2022.] https://datastudio.google.com/overview.

31. —. Connect to Data. *Google Data Studio.* [Online] [Cited: March 5, 2022.] https://datastudio.google.com/data.

32. —. Visualizations. *Google Data Studio.* [Online] [Cited: March 5, 2022.] https://datastudio.google.com/visualization.

33. —. Gallery. *Google Data Studio.* [Online] [Cited: March 5, 2022.] https://datastudio.google.com/gallery.

34. **Google Developers.** Data Studio Community Connectors. *Google Developers.* [Online] January 30, 2019. [Cited: March 5, 2022.] https://developers.google.com/datastudio/connector.

35. —. Data Studio Community Visualizations. *Google Developers.* [Online] April 7, 2020. [Cited: March 5, 2022.] https://developers.google.com/datastudio/visualization.

36. **QlikTech International AB.** BI Reporting and Analytics Benefits | Qlik. *Qlik | Analytics & Data Integration Platform.* [Online] 2022. [Cited: March 18, 2022.] https://www.qlik.com/us/reporting-analytics.

37. **Christiansen, Emily.** The Success Stories You Probably Haven't Heard Of: Qlik. *News - Øresund Startups.* [Online] April 27, 2014. [Cited: March 12, 2022.] https://oresundstartups.com/success-stories-might-missed-qlik/.

38. **QlikTech International AB.** Analytics & Data Integration Platform. *Qlik.* [Online] 2022. [Cited: March 18, 2022.] https://www.qlik.com/us/.

39. —. Connecting to data sources – Qlik Sense on Windows. *Qlik | Help.* [Online] February 2022. [Cited: March 23, 2022.] https://help.qlik.com/en-US/sense/February2022/Subsystems/Hub/Content/Sense_Hub/LoadData/connect-data-sources.htm.

40. —. Visualizations – Qlik Sense on Windows. *Qlik | Help.* [Online] February 2022. [Cited: March 22, 2022.] https://help.qlik.com/en-US/sense/February2022/Subsystems/Hub/Content/Sense_Hub/Visualizations/visualizations.htm.

41. —. Visualization bundle – Qlik Sense on Windows. *Qlik | Help.* [Online] February 2022. [Cited: March 22, 2022.] https://help.qlik.com/en-US/sense/February2022/Subsystems/Hub/Content/Sense_Hub/Visualizations/VisualizationBundle/visualization-bundle.htm.

42. —. Custom connectors – Qlik Sense for developers. *Qlik | Help.* [Online] August 2021. [Cited: March 23, 2022.] https://help.qlik.com/en-US/sense-developer/August2021/Subsystems/QVXSDKAPI/Content/Sense_QVXSDKAPI/Introducing-QVX.htm.

43. —. Extending with custom visualization objects – Qlik Sense for developers. *Qlik | Help.* [Online] Ferbuary 2022. [Cited: March 22, 2022.] https://help.qlik.com/en-US/sense-developer/August2021/Content/Sense_Helpsites/extend-qlik-sense.htm.

44. **Rad, Reza.** *Pro Power BI Architecture.* Berkeley : Apress, 2018. 978-1-4842-4014-4.

45. **Microsoft.** What is Power BI? - Power BI. *Microsoft Docs.* [Online] January 29, 2022. [Cited: February 20, 2022.] https://docs.microsoft.com/en-us/power-bi/fundamentals/power-bi-overview.

46. —. A Glimpse at Project Crescent. *Microsoft Docs.* [Online] November 9, 2010. [Cited: February 21, 2022.] https://docs.microsoft.com/en-us/archive/blogs/sqlrsteamblog/a-glimpse-at-project-crescent.

47. **The Power BI Team.** Announcing Power BI general availability coming July 24th | Microsoft Power BI Blog. *Microsoft Power BI.* [Online] July 10, 2015. [Cited: February 15, 2022.] https://powerbi.microsoft.com/en-us/blog/announcing-power-bi-general-availability-coming-july-24th.

48. **Microsoft.** Power BI Desktop-Interactive Reports. *Microsoft Power BI.* [Online] [Cited: February 25, 2022.] https://powerbi.microsoft.com/en-us/desktop/.

49. —. Mobile. *Microsoft Power BI.* [Online] [Cited: February 25, 2022.] https://powerbi.microsoft.com/en-us/mobile/.

50. **Apple.** Microsoft Power BI on the App Store. *App Store - Apple.* [Online] [Cited: February 25, 2022.] https://apps.apple.com/app/microsoft-power-bi/id929738808.

51. **Microsoft.** Get Power BI. *Microsoft Store.* [Online] [Cited: February 25, 2022.] https://www.microsoft.com/en-us/p/power-bi/9nblgggzlxn1.

52. **Google.** Microsoft Power BI–Business data analytics. *Apps on Google Play.* [Online] [Cited: February 25, 2022.] https://play.google.com/store/apps/details?id=com.microsoft.powerbim.

53. **Microsoft.** Power BI Embedded Analytics. *Microsoft Azure.* [Online] [Cited: February 25, 2022.] https://azure.microsoft.com/en-us/services/power-bi-embedded.

54. **Micorosft.** Power BI Report Server. *Microsoft Power BI.* [Online] [Cited: February 25, 2022.] https://powerbi.microsoft.com/en-us/report-server/.

55. **Puls, Ken and Escobar, Miguel.** *M is for (DATA) MONKEY.* Merritt Island : Holy Macro! Books, 2015. 978-1-61547-034-1.

56. **Microsoft.** Power BI data sources - Power BI . *Microsoft Docs.* [Online] [Cited: February 27, 2022.] https://docs.microsoft.com/en-us/power-bi/connect-data/power-bi-data-sources.

57. —. Main sources for acquiring Power BI visuals - Power BI. *Microsoft Docs.* [Online] [Cited: March 19, 2022.] https://docs.microsoft.com/en-us/power-bi/developer/visuals/power-bi-custom-visuals.

58. —. Business Apps. *Microsoft AppSource.* [Online] [Cited: March 19, 2022.] https://appsource.microsoft.com/en-US/marketplace/apps?page=1&product=power-bi-visuals.

59. —. Get samples for Power BI - Power BI. *Microsoft Docs.* [Online] April 2, 2022. [Cited: March 1, 2022.] https://docs.microsoft.com/en-us/power-bi/create-reports/sample-datasets.

60. —. Developing custom visuals in Power BI - Power BI. *Microsoft Docs.* [Online] January 15, 2022. [Cited: March 19, 2022.] https://docs.microsoft.com/en-us/power-bi/developer/visuals/develop-power-bi-visuals.

61. —. Power Query SDK. *Visual Studio Marketplace.* [Online] May 5, 2017. [Cited: March 19, 2022.] https://marketplace.visualstudio.com/items?itemName=Dakahn.PowerQuerySDK.

62. —. Start developing custom connectors for Power Query - Power Query. *Microsoft Docs.* [Online] March 1, 2022. [Cited: March 19, 2022.] https://docs.microsoft.com/en-us/power-query/startingtodevelopcustomconnectors.

63. **Tableau Software.** Business Intelligence and Analytics Software. [Online] [Cited: March 4, 2022.] https://www.tableau.com/.

64. —. What Is Tableau? | Tableau. *Business Intelligence and Analytics Software.* [Online] [Cited: March 5, 2022.] https://www.tableau.com/why-tableau/what-is-tableau.

65. —. Salesforce Completes Acquisition of Tableau. *Business Intelligence and Analytics Software.* [Online] August 1, 2019. [Cited: March 5, 2022.] https://www.tableau.com/about/press-releases/2019/salesforce-completes-acquisition-tableau.

66. —. Tableau Prep Builder & Prep Conductor: A self-service data preparation solution. *Business Intelligence and Analytics Software.* [Online] [Cited: March 4, 2022.] https://www.tableau.com/products/prep.

67. —. Tableau Public. *Business Intelligence and Analytics Software.* [Online] [Cited: March 4, 2022.] https://www.tableau.com/products/public.

68. —. Tableau Desktop. *Business Intelligence and Analytics Software.* [Online] [Cited: March 4, 2022.] https://www.tableau.com/products/desktop.

69. —. Tableau Server | Access Insight Anywhere. *Business Intelligence and Analytics Software.* [Online] [Cited: March 4, 2022.] https://www.tableau.com/products/server.

70. —. Tableau Online | SaaS Analytics For Everyone. *Business Intelligence and Analytics Software.* [Online] [Cited: March 4, 2022.] https://www.tableau.com/products/cloud-bi.

71. **Apple.** Tableau Mobile on the App Store. *App Store - Apple.* [Online] [Cited: March 4, 2022.] https://apps.apple.com/us/app/tableau-mobile/id434633927.

72. **Google.** Tableau Mobile - Apps on Google Play. *Apps on Google Play.* [Online] [Cited: March 4, 2022.] https://play.google.com/store/apps/details?id=com.Tableau.TableauApp.

73. **Tableau Software.** Tableau CRM. *Business Intelligence and Analytics Software.* [Online] [Cited: March 4, 2022.] https://www.tableau.com/products/tableau-crm.

74. —. Supported Connectors - Tableau. *Online Help | Tableau Software.* [Online] [Cited: March 5, 2022.] https://help.tableau.com/current/pro/desktop/en-us/exampleconnections_overview.htm.

75. —. Tableau Exchange. [Online] [Cited: March 5, 2022.] https://extensiongallery.tableau.com/connectors?version=2021.2.

76. —. Visual Analytics: Families, Types & Importance | Tableau. *Business Intelligence and Analytics Software.* [Online] [Cited: March 5, 2022.] https://www.tableau.com/data-insights/reference-library/visual-analytics.

77. —. Tableau Exchange. [Online] [Cited: March 5, 2022.] https://exchange.tableau.com/extensions?version=2021.2.

78. —. Use Partner-Built Connector from the Tableau Exchange - Tableau. *Online Help | Tableau Software.* [Online] [Cited: March 5, 2022.] https://help.tableau.com/current/pro/desktop/en-us/gallery_connectors.htm.

79. —. Tableau Connector SDK. *Tableau Open Source.* [Online] [Cited: March 5, 2022.] https://tableau.github.io/connector-plugin-sdk/docs/.

80. —. Get Started with Dashboard Extensions. *Tableau Open Source.* [Online] [Cited: March 5, 2022.] https://tableau.github.io/extensions-api/docs/trex_getstarted.html#get-the-tableau-extensions-api-sdk.

81. —. Our Platform. *Business Intelligence and Analytics Software.* [Online] [Cited: March 4, 2022.] https://www.tableau.com/products/our-platform.

82. **Gartner.** Magic Quadrant Research Methodology | Gartner. *Gartner | Delivering Actionable, Objective Insight to Executives and Their Teams.* [Online] [Cited: March 19, 2022.] https://www.gartner.com/en/research/methodologies/magic-quadrants-research.

83. —. How Markets and Vendors Are Evaluated in Gartner Magic Quadrants. *Gartner | Delivering Actionable, Objective Insight to Executives and Their Teams.* [Online] August 15, 2019. [Cited: March 19, 2022.] https://www.gartner.com/en/documents/3956304.

84. **Kronz, Austin, et al.** Magic Quadrant for Analytics and Business Intelligence Platforms. *Gartner | Delivering Actionable, Objective Insight to Executives and Their*

Teams. [Online] March 22, 2022. [Cited: April 1, 2022.] https://www.gartner.com/doc/reprints?id=1-292LEME3&ct=220209&st=sb.

85. **Richardson, James, et al.** Magic Quadrant for Analytics and Business Intelligence Platforms. *Gartner | Delivering Actionable, Objective Insight to Executives and Their Teams.* [Online] February 15, 2021. [Cited: March 19, 2022.] https://www.gartner.com/doc/reprints?id=1-24ZXJ0MU&ct=210107&st=sb.

86. *History and Perspectives of Elearning.* **Hubackova, Sarka.** June 2, 2015, Procedia - Social and Behavioral Sciences, Vol. 191, pp. 1187-1990.

87. **Ellis, Ryann K.** *Field Guide to Learning Management Systems.* s.l. : American Society for Training & Development, 2009.

88. **G2.** Best Learning Management Systems in 2022: Compare Reviews on 190+ Software. *G2.* [Online] [Cited: February 20, 2022.] https://www.g2.com/categories/learning-management-system-lms.

89. —. Best Corporate Learning Management Systems in 2022. *G2.* [Online] [Cited: February 20, 2022.] https://www.g2.com/categories/corporate-learning-management-systems.

90. **Adobe.** Reference manual for Integration Administrators who want to migrate an existing LMS to Captivate Prime LMS. *Adobe Help Center.* [Online] October 18, 2021. [Cited: March 17, 2022.] https://helpx.adobe.com/ie/captivate-prime/integration-admin/feature-summary/migration-manual.html.

91. **G2.** G2 Research Scoring Methodologies. *G2 Research Hub.* [Online] [Cited: February 20, 2022.] https://research.g2.com/methodology/scoring.

92. **Adobe.** Adobe Captivate Prime LMS. *Adobe: Creative, marketing and document management solutions.* [Online] 2022. [Cited: March 10, 2022.] https://www.adobe.com/products/captivateprime.html.

93. —. Adobe Captivate Prime LMS - All features. *Adobe: Creative, marketing and document management solutions.* [Online] 2021. [Cited: February 21, 2022.] https://www.adobe.com/products/captivateprime/features/all-features.html.

94. —. Adobe Captivate Prime LMS - Awards. *Adobe: Creative, marketing and document management solutions.* [Online] 2022. [Cited: March 17, 2022.] https://www.adobe.com/products/captivateprime/awards.html.

95. —. Integrate connectors with Captivate Prime. *Adobe Help Center.* [Online] January 15, 2022. [Cited: March 17, 2022.] https://helpx.adobe.com/ie/captivate-prime/integration-admin/feature-summary/connectors.html.

96. —. Captivate Prime API. *Adobe Captivate Prime.* [Online] [Cited: March 17, 2022.] https://captivateprime.adobe.com/docs/primeapi/v2/.

97. —. Application developer manual. *Adobe Help Center.* [Online] October 18, 2021. [Cited: March 17, 2022.] https://helpx.adobe.com/ie/captivate-prime/integration-admin/feature-summary/developer-manual.html.

98. **Microsoft.** What is Power Query? - Power Query. *Microsoft Docs.* [Online] March 1, 2022. [Cited: March 21, 2022.] https://docs.microsoft.com/en-us/power-query/power-query-what-is-power-query.

99. —. Power Query M function reference - PowerQuery M. *Microsoft Docs.* [Online] January 19, 2022. [Cited: March 21, 2022.] https://docs.microsoft.com/en-us/powerquery-m/power-query-m-function-reference.

100. **Powell, Brett.** *Microsoft Power BI Cookbook.* Birmingham : Packt, 2017. 978-1-78829-014-2.

101. **Daniel, Elman., et al.** Embedded Analytics Technology Value Matrix 2021. *Nucleus Research.* [Online] November 2, 2021. [Cited: April 5, 2022.] https://nucleusresearch.com/research/single/embedded-analytics-technology-value-matrix-2021/.

102. **Microsoft.** Pricing & Product Comparison. *Microsoft Power BI.* [Online] 2022. [Cited: April 1, 2022.] https://powerbi.microsoft.com/en-us/pricing/.

103. **Tableau Software.** Tableau Pricing for Teams & Organizations. *Business Intelligence and Analytics Software.* [Online] 2022. [Cited: April 1, 2022.] https://www.tableau.com/pricing/teams-orgs#online.

104. **QlikTech International AB.** Qlik Pricing | Qlik Sense – Compare All Editions. *Qlik | Analytics & Data Integration Platform.* [Online] 2022. [Cited: April 1, 2022.] https://www.qlik.com/us/pricing.

105. —. About Qlik Connectors – Qlik Connectors. *Qlik | Help.* [Online] 2022. [Cited: April 1, 2022.] https://help.qlik.com/en-US/connectors/Content/Connectors_Home/Home.htm.

106. **Microsoft.** Visualization types in Power BI - Power BI. *Microsoft Docs.* [Online] November 9, 2022. [Cited: April 1, 2022.] https://docs.microsoft.com/en-us/power-bi/visuals/power-bi-visualization-types-for-reports-and-q-and-a.

107. **Tableau Software.** Build Common Chart Types in Data Views - Tableau. *Tableau Help | Tableau Software.* [Online] 2022. [Cited: April 1, 2022.] https://help.tableau.com/current/pro/desktop/en-us/dataview_examples.htm.

108. —. Analytics How To's - Tableau. *Tableau Help | Tableau Software.* [Online] 2022. [Cited: April 1, 2022.] https://help.tableau.com/current/pro/desktop/en-us/analytics_howtos.htm.

109. **Microsoft.** What is Augmented Analytics | Microsoft Power BI. *Data Visualization | Microsoft Power BI.* [Online] 2022. [Cited: April 1, 2022.] https://powerbi.microsoft.com/en-us/augmented-analytics/.

110. **Tableau Software.** Einstein Discovery. *Business Intelligence and Analytics Software.* [Online] 2022. [Cited: April 1, 2022.] https://www.tableau.com/products/add-ons/einstein-discovery.

111. **QlikTech International AB.** AI & Machine Learning Capabilities | Qlik. *Qlik | Analytics & Data Integration Platform.* [Online] 2022. [Cited: April 1, 2022.] https://www.qlik.com/us/products/qlik-sense/ai.

112. **Microsoft.** Explore our APIs. *Power BI Playground.* [Online] 2022. [Cited: April 4, 2022.] https://playground.powerbi.com/en-us/explore-features.

113. **Tableau Software.** Powered by Tableau | Create. Embed. Grow | Tableau Software Embedded Analytics. *Business Intelligence and Analytics Software.* [Online] 2022. [Cited: April 1, 2022.] https://www.tableau.com/embedded-analytics.

114. **QlikTech International AB.** Embedded Analytics | Qlik. *Qlik | Analytics & Data Integration Platform.* [Online] 2022. [Cited: April 1, 2022.] https://www.qlik.com/us/bi/embedded-analytics.

115. —. Qlik Sense – Mobile Analytics | Qlik. *Qlik | Analytics & Data Integration Platform.* [Online] 2022. [Cited: April 1, 2022.] https://www.qlik.com/us/products/qlik-sense/mobile-analytics.

116. **Tableau Software.** Tableau Mobile. *Business Intelligence and Analytics Software.* [Online] 2022. [Cited: April 1, 2022.] https://www.tableau.com/products/mobile.

117. **Microsoft.** Power BI + Azure | Microsoft Power Platform. *Data Visualization | Microsoft Power BI.* [Online] 2022. [Cited: April 1, 2022.] https://powerbi.microsoft.com/en-us/power-bi-and-azure/.

118. **Tableau Software.** Tableau Deployment - Tableau. *Online Help | Tableau Software.* [Online] 2022. [Cited: April 1, 2022.] https://help.tableau.com/current/blueprint/en-us/bp_deployment.htm.

119. **Microsoft.** Power BI Custom Visuals – Data Visualization Tools | Power BI. *Data Visualization | Microsoft Power BI.* [Online] 2022. [Cited: April 1, 2022.] https://powerbi.microsoft.com/en-us/developers/custom-visualization/.

120. —. Home. *Microsoft Power BI Community.* [Online] [Cited: April 1, 2022.] https://community.powerbi.com/.

121. —. Power BI on Microsoft Learn. *Microsoft Docs.* [Online] 2022. [Cited: April 2, 2022.] https://docs.microsoft.com/en-gb/learn/powerplatform/power-bi.

122. **Tableau Software.** Start your Journey. *Business Intelligence and Analytics Software.* [Online] 2022. [Cited: April 1, 2022.] https://www.tableau.com/learn/start-your-journey.

123. **QlikTech International AB.** Qlik Learning: Search. *Qlik Learning Portal.* [Online] 2022. [Cited: April 4, 2022.] https://learning.qlik.com/mod/page/view.php?id=24708.

124. —. Home. *Qlik Community.* [Online] 2022. [Cited: April 3, 2022.] https://community.qlik.com/.

125. **Stanke, Luke, et al.** #WorkoutWednesday. *Workout Wednesday.* [Online] 2022. [Cited: April 4, 2022.] https://www.workout-wednesday.com/.

126. **Microsoft.** Browse Certifications and Exams. *Microsoft Docs.* [Online] 2022. [Cited: April 3, 2022.] https://docs.microsoft.com/en-us/learn/certifications/browse/?filter-products=power%20bi&products=power-bi.

127. **Tableau Software.** Certification. *Business Intelligence and Analytics Software.* [Online] 2022. [Cited: April 3, 2022.] https://www.tableau.com/learn/certification.

128. **Microsoft.** Get Power BI Desktop - Power BI. *Microsoft Docs.* [Online] February 2, 2022. [Cited: March 23, 2022.] https://docs.microsoft.com/en-us/power-bi/fundamentals/desktop-get-the-desktop.

129. —. Download Microsoft Power BI Desktop from Official Microsoft Download Center. *Microsoft Download Center: Windows, Office, Xbox & More.* [Online] March 28, 2022. [Cited: March 29, 2022.] https://www.microsoft.com/en-us/download/details.aspx?id=58494.

130. —. Power Query SDK. *Visual Studio Marketplace.* [Online] August 18, 2019. [Cited: March 23, 2022.] https://marketplace.visualstudio.com/items?itemName=Dakahn.PowerQuerySDK.

131. —. IDE and Code Editor for Software Developers and Teams. *Visual Studio.* [Online] [Cited: March 25, 2022.] https://visualstudio.microsoft.com/.

132. —. Install Visual Studio. *Microsoft Docs.* [Online] November 20, 2021. [Cited: March 25, 2022.] https://docs.microsoft.com/en-us/visualstudio/install/install-visual-studio?view=vs-2019.

133. —. Power Query Connector Certification - Power Query. *Microsoft Docs.* [Online] April 4, 2022. [Cited: April 4, 2022.] https://docs.microsoft.com/en-us/power-query/connectorcertification.

134. —. Versioning for Power Query connectors - Power Query. *Microsoft Docs.* [Online] March 1, 2022. [Cited: April 3, 2022.] https://docs.microsoft.com/en-us/power-query/handlingversioning.

8. List of Pictures, Tables, Graphs, and Abbreviations

8.1. List of Pictures

8.2. List of Tables

8.3. List of Abbreviations

ABI: ....Analytics and Business Intelligence

AI: .... Artificial Intelligence

API: ....Application Programming Interface

BI: ....Business Intelligence

CBT: ....Computer-Based Training

CPU: ....Central Processing Unit

CRM: .... Customer Relationship Management

CSS: ....Cascading Style Sheets

CSV: ....Comma-separated values

DAX: ....Data Analysis Expression

FTP: ....File Transfer Protocol

GPL-3.0: ....GNU General Public License v3.0

HR: ....Human Resources

HTML: .... Hypertext Markup Language

HTTP: ....Hypertext Transfer Protocol

IAM: .... Identity and Access Management

IDE: .... Integrated Development eEnvironment

INCOSE: ....International Council on Systems Engineering

IT: ....Information Technology

JDBC .... Java Database Connectivity

JS: .... JavaScript

JSON: ....JavaScript Object Notation

KPI: .... Key Performance Indicator

LMS: ....Learning Management System

ML: .... Machine Learning

NASA: ....The National Aeronautics and Space Administration

Oauth: .... Open Authorization

OData .... Open Data Protocol

ODBC: ....open database connectivity

OS: .... Operating System

P&L: ....profit and loss statement

77

9. Appendix

Appendix A   Redacted copy of the conversation about proprietary asset use permission

Appendix B   Embedded Analytics Technology Value Matrix 2021 by Nucleus Research

Appendix C   Minimum Requirements of Microsoft Power BI Desktop

Appendix D   Microsoft Visual Studio 2019 System Requirements

Appendix E   Power BI Security options for uncertified custom data connectors

Appendix F   Power BI messages for uncertified custom data connectors

Appendix G   Power BI messages for beta-staged custom data connectors

Appendix H   Detailed flowchart diagram of the final program

Appendix I   Final version of the source code: "resources.resx"

Appendix J   Final version of the source code: "AdobeCaptivatePrime.pq"

From: Dilo Kruyswijk <dilo.kruyswijk@nmqdigital.com>
Sent: 22 March, 2022 07:47
To: Karabulut Emre (S-PEF) <xkare019@studenti.czu.cz>
Cc: ████████████████ Emre KARABULUT; █████████████
Subject: RE: Requesting permission to use NMQ Digital's name (NO DATA) in the case study in my diploma thesis.

Emre,

Good to hear from you and good to see you progress on the academic level!
You have my approval to use the Name NMQ Digital as a reference.
Good luck and have fun,

Dilo

> **From:**   Karabulut Emre (S-PEF) <XKARE019@studenti.czu.cz>
> **Sent:**   Tuesday, 22 March 2022 03:02
> **To:**   Dilo Kruyswijk <dilo.kruyswijk@nmqdigital.com>
> **Cc:**   ██████████████████████████████████ ;
> Emre KARABULUT <karabulutemre@gmail.com>
>
> **Subject:** Requesting permission to use NMQ Digital's name (NO DATA) in the case study in my diploma thesis.
>
> Dear Dilo,
>
> I hope everything is going well for you and your family since our last conversation.
>
> ████████████████████████████████████
> ████████████████████████████████████
> ████████████████████████
>
> Since it is a proprietary asset, I'd like to have NMQ's permission to use it in my diploma thesis.
>
> ████████████████████████████████████
>
> ███████████████
>
> I'm looking forward to your answer.
>
> Best regards,
> Emre KARABULUT

Appendix B   Embedded Analytics Technology Value Matrix 2021 by Nucleus Research

The following list provides the minimum requirements to run Power BI Desktop[1]:

- Windows 8.1 / Windows Server 2012 R2, or later
- .NET 4.6.2 or later
- Internet Explorer 11 or later
- Memory (RAM): At least 2 GB available, 4 GB or more recommended.
- Display: At least 1440x900 or 1600x900 (16:9) required. Lower resolutions such as 1024x768 or 1280x800 aren't supported, as certain controls (such as closing the startup screen) display beyond those resolutions.
- Windows display settings: If you set your display settings to change the size of text, apps, and other items to more than 100%, you may not be able to see certain dialogs that you must interact with to continue using Power BI Desktop. If you encounter this issue, check your display settings in Windows by going to Settings > System > Display, and use the slider to return display settings to 100%.
- CPU: 1 gigahertz (GHz) 64-bit (x64) processor or better recommended.
- WebView2, if not automatically installed with Power BI Desktop or uninstalled. Download and run the installer for WebView2[2].

---

[1] https://docs.microsoft.com/en-us/power-bi/fundamentals/desktop-get-the-desktop#minimum-requirements
[2] https://go.microsoft.com/fwlink/p/?LinkId=2124703

Visual Studio Community 2019 supports the minimum system requirements below[1]:

Supported Operating Systems:

Visual Studio 2019 will install and run on the following operating systems (64 bit recommended; ARM is not supported):

- Windows 10 version 1703 or higher: Home, Professional, Education, and Enterprise (LTSC and S are not supported)
- Windows Server 2019: Standard and Datacenter
- Windows Server 2016: Standard and Datacenter
- Windows 8.1 (with Update 2919355[2]): Core, Professional, and Enterprise
- Windows Server 2012 R2 (with Update 2919355[3]): Essentials, Standard, Datacenter
- Windows 7 SP1 (with latest Windows Updates): Home Premium, Professional, Enterprise, Ultimate

Hardware:

- 1.8 GHz or faster processor. Quad-core or better recommended
- 2 GB of RAM; 8 GB of RAM recommended (2.5 GB minimum if running on a virtual machine)
- Hard disk space: Minimum of 800MB up to 210 GB of available space, depending on features installed; typical installations require 20-50 GB of free space.
- Hard disk speed: to improve performance, install Windows and Visual Studio on a solid-state drive (SSD).
- Video card that supports a minimum display resolution of 720p (1280 by 720); Visual Studio will work best at a resolution of WXGA (1366 by 768) or higher. Windows 8.1 / Windows Server 2012 R2, or later

---

[1] https://docs.microsoft.com/en-us/visualstudio/releases/2019/system-requirements#visual-studio-2019-system-requirements
[2] https://support.microsoft.com/kb/2919355
[3] https://support.microsoft.com/kb/2919355

Appendix E   Power BI Security options for uncertified custom data connectors

Appendix F   Power BI messages for uncertified custom data connectors

Uncertified Connectors

The following connector has not been certified, and we are unable to verify that it is secure to use:

AdobeCaptivatePrime

If it was provided by a vendor, please request that they contact Microsoft about the Certified Connector program. If you would still like to use it, please enable a lower data extension setting under the Security tab in the Options dialog, and restart Power BI Desktop.

OK

Appendix G   Power BI messages for beta-staged custom data connectors

Connecting to a third-party service

The Adobe Captivate Prime connector relies on a third-party service and is still under development. Please try it out and give us feedback. We can't guarantee it will work the same way in the final version. Future changes may cause your queries to be incompatible.

Learn more about the service used for the Adobe Captivate Prime connector

☐ Don't warn me again for this connector

[Continue] [Cancel]

Appendix I   Final version of the source code: "resources.resx"

Name	Value	Comment
AuthenticationKeyKeyLabel	access_token	
AuthenticationKeyLabel	API (v2)	
ButtonHelp	Connect to Adobe Captivate Prime APIs	
ButtonTitle	Adobe Captivate Prime	
DataSourceLabel	Adobe Captivate Prime API	
TablesDocsExamplesCode	AdobeCaptivatePrime.Tables(""server_instance"")	
TablesDocsExamplesDesc	Returns a table with available itemKinds for nav tree.	
TablesDocsExamplesResult	#table({""Name"", ""Key"", ""Data"", ""ItemKind"", ""ItemName"", ""IsLeaf""})	
TablesDocsFieldCaption	Server Instance	
TablesDocsFieldDesc	Please enter the server instance address.	
TablesDocsLongDesc	This function provides a Navigation Table to select desired itemKinds.	
TablesDocsName	Captivate Prime API	
TablesDocsSampleValues	captivateprimeeu	

Appendix J   Final version of the source code: "AdobeCaptivatePrime.pq"

```
1   [Version = "1.0.0"] // Requirement for certification
2
3   section AdobeCaptivatePrime;
4   [DataSource.Kind="AdobeCaptivatePrime", Publish="AdobeCaptivatePrime.Publish"]
5
6   shared AdobeCaptivatePrime.Navigator = Value.ReplaceType(AdobeCaptivatePrimeImpl,
    AdobeCaptivatePrimeType);
7
8       AdobeCaptivatePrimeType =  type function (
9           server_instance as (type text meta [
10              Documentation.FieldCaption = Extension.LoadString("TablesDocsFieldCaption"),
11              Documentation.FieldDescription = Extension.LoadString("TablesDocsFieldDesc"),
12              Documentation.SampleValues =
    Table.ToList(Table.FromValue(Extension.LoadString("TablesDocsSampleValues"))),
13              Formatting.IsMultiLine = false,
14              Formatting.IsCode = false
15              ])) as table meta [
16                  Documentation.Name = Extension.LoadString("TablesDocsName"),
17                  Documentation.LongDescription = Extension.LoadString("TablesDocsLongDesc"),
18                  Documentation.Examples = {[
19                      Description = Extension.LoadString("TablesDocsExamplesDesc"),
20                      Code = Extension.LoadString("TablesDocsExamplesCode"),
21                      Result = Extension.LoadString("TablesDocsExamplesResult")
22                  ]}
23              ];
24
25      AdobeCaptivatePrimeImpl = (server_instance as text) =>
26          let
27              objects = #table(
28                  {"Name", "Key", "Data", "ItemKind", "ItemName", "IsLeaf"},{
29                  {"Badges", "badges", AdobeCaptivatePrime.Tables(server_instance, "badges"),
    "Table", "Table", true},
30                  {"Users", "users", AdobeCaptivatePrime.Tables(server_instance, "users"),
    "Table", "Table", true},
31                  {"UserGroups", "userGroups", AdobeCaptivatePrime.Tables(server_instance,
    "userGroups"), "Table", "Table", true},
32                  {"Catalogs", "catalogs", AdobeCaptivatePrime.Tables(server_instance,
    "catalogs"), "Table", "Table", true},
33                  {"Skills", "skills", AdobeCaptivatePrime.Tables(server_instance, "skills"),
    "Table", "Table", true},
34                  {"LearningObjects", "learningObjects",
    AdobeCaptivatePrime.Tables(server_instance, "learningObjects"), "Table", "Table", true},
35                  {"getUserBadges", "getuserbadges", AdobeCaptivatePrime.getUserBadges,
    "Function", "Function", true},
36                  {"getUserEnrollments", "getUserEnrollments",
    AdobeCaptivatePrime.getUserEnrollments, "Function", "Function", true}
37                  }),
38              NavTable = Table.ToNavigationTable(objects, {"Key"}, "Name", "Data", "ItemKind",
    "ItemName", "IsLeaf")
39          in
40              NavTable;
41
42   shared AdobeCaptivatePrime.Tables = (server_instance as text, endpoint as text) as table =>
43       let
44           Records = GetAllPagesByNextLink("https://" & server_instance &
    ".adobe.com/primeapi/v2/" & endpoint),
45           Table = ExpandAttributes(Records)
46       in
47           Table;
48
49   shared AdobeCaptivatePrime.getUserBadges = (server_instance as text, userId as text) as table
    =>
50       let
51           Records = GetAllPagesByNextLink("https://" & server_instance &
    ".adobe.com/primeapi/v2/users/" & userId & "/userBadges"),
52           Table = ExpandAttributes(Records)
```

```
53          in
54              Table;
55
56      shared AdobeCaptivatePrime.getUserEnrollments = (server_instance as text, userId as text) as
        table =>
57          let
58              Records = GetAllPagesByNextLink("https://" & server_instance &
        ".adobe.com/primeapi/v2/users/" & userId &
        "/enrollments?filter.loTypes=course%2ClearningProgram%2CjobAid%2Ccertification"),
59              Table = ExpandAttributes(Records)
60          in
61              Table;
62
63      DefaultRequestHeaders = [
64          #"Authorization" = "oauth " & Extension.CurrentCredential()[Key],
65          #"Accept" = "application/vnd.api+json"
66      ];
67
68      AdobeCaptivatePrime = [
69          Authentication = [
70              Key = [
71                  KeyLabel = Extension.LoadString("AuthenticationKeyKeyLabel"),
72                  Label =  Extension.LoadString("AuthenticationKeyLabel")
73              ]
74          ],
75          Label = Extension.LoadString("DataSourceLabel")
76      ];
77
78      AdobeCaptivatePrime.Publish = [
79          Beta = true, // Soft requirement for certification
80          Category = "Online Services",
81          ButtonText = { Extension.LoadString("ButtonTitle"), Extension.LoadString("ButtonHelp") },
82          LearnMoreUrl = "https://github.com/karabulute/powerbi-dataconnector-adobecaptivateprime",
83          SourceImage = AdobeCaptivatePrime.Icons,
84          SourceTypeImage = AdobeCaptivatePrime.Icons
85      ];
86
87      AdobeCaptivatePrime.Icons = [ // Soft requirement for certification
88          Icon16 = {
89              Extension.Contents("AdobeCaptivatePrime16.png"),
90              Extension.Contents("AdobeCaptivatePrime20.png"),
91              Extension.Contents("AdobeCaptivatePrime24.png"),
92              Extension.Contents("AdobeCaptivatePrime32.png")
93          },
94          Icon32 = {
95              Extension.Contents("AdobeCaptivatePrime32.png"),
96              Extension.Contents("AdobeCaptivatePrime40.png"),
97              Extension.Contents("AdobeCaptivatePrime48.png"),
98              Extension.Contents("AdobeCaptivatePrime64.png")
99          }
100     ];
101
102     GetPage = (url as text) as table =>
103         let
104             response = Web.Contents(url, [ Headers = DefaultRequestHeaders ]),
105             body = Json.Document(response),
106             nextLink = GetNextLink(body),
107             data = Table.FromRecords(body[data])
108         in
109             data meta [NextLink = nextLink];
110
111     GetNextLink = (response) as nullable text =>  try response[links][next] otherwise null;
112
113     GetAllPagesByNextLink = (url as text) as table =>
114         Table.GenerateByPage((previous) =>
115             let
116                 nextLink = if (previous = null) then url else Value.Metadata(previous)[NextLink]?,
117                 page = if (nextLink <> null) then GetPage(nextLink) else null
```

```
118             in
119                 page
120         );
121
122     ExpandAttributes = (records as table) as table =>
123         let
124             ExpandedRecords = if Table.HasColumns(records, "attributes")
125                 then Table.ExpandRecordColumn(records, "attributes",
     Record.FieldNames(records{0}[attributes]))
126                 else records
127         in
128             ExpandedRecords;
129
130     Table.ToNavigationTable = (
131         table as table,
132         keyColumns as list,
133         nameColumn as text,
134         dataColumn as text,
135         itemKindColumn as text,
136         itemNameColumn as text,
137         isLeafColumn as text
138     ) as table =>
139         let
140             tableType = Value.Type(table),
141             newTableType = Type.AddTableKey(tableType, keyColumns, true) meta
142             [
143                 NavigationTable.NameColumn = nameColumn,
144                 NavigationTable.DataColumn = dataColumn,
145                 NavigationTable.ItemKindColumn = itemKindColumn,
146                 Preview.DelayColumn = itemNameColumn,
147                 NavigationTable.IsLeafColumn = isLeafColumn
148             ],
149             navigationTable = Value.ReplaceType(table, newTableType)
150         in
151             navigationTable;
152
153     Table.GenerateByPage = (getNextPage as function) as table =>
154         let
155             listOfPages = List.Generate(
156                 () => getNextPage(null),
157                 (lastPage) => lastPage <> null,
158                 (lastPage) => getNextPage(lastPage)
159             ),
160             tableOfPages = Table.FromList(listOfPages, Splitter.SplitByNothing(), {"Column1"}),
161             firstRow = tableOfPages{0}?
162         in
163             if (firstRow = null) then
164                 Table.FromRows({})
165             else
166                 Value.ReplaceType(
167                     Table.ExpandTableColumn(tableOfPages, "Column1",
     Table.ColumnNames(firstRow[Column1])),
168                     Value.Type(firstRow[Column1])
169                     )
```