

DASHBOARDS WITH
PLOTLY
& DASH

★★★★★ *With Expert Python Instructor Chris Bruehl*



COURSE STRUCTURE



This is a **project-based** course for students looking for a practical, hands-on approach to learning Plotly and Dash for building interactive visualizations & dashboards using Python

Additional resources include:

- ★ **Downloadable PDF** to serve as a helpful reference when you're offline or on the go
- ★ **Quizzes & Assignments** to test and reinforce key concepts, with step-by-step solutions
- ★ **Interactive demos** to keep you engaged and apply your skills throughout the course

COURSE OUTLINE

1

Intro to Plotly & Dash

Introduce the Plotly & Dash libraries, and cover the key steps & components for creating a basic Dash application with interactive Plotly visuals

2

Plotly Figures & Chart Types

Dive deep into the Plotly library and use it to build & customize several chart types, including line charts, bar charts, pie charts, scatterplots, and histograms

3

Interactive Elements

Get comfortable embedding Dash's interactive elements into your application, and using them to manipulate Plotly Visualizations



PROJECT: Interactive Ski Resort Visualizations

4

Dashboard Layouts

Learn how to organize your visualizations and interactive components into a visually appealing and logical structure

5

Advanced Functionality

Take your applications to the next level by learning how to update your application with real-time data, develop chained-callback functions, and more!



PROJECT: Building A Dashboard to Help Agents Find The Best Ski resorts For Customers

THE COURSE PROJECT



THE SITUATION

You've just been hired to join the Analytics team at **Maveluxe Travel**, a high-end travel agency with best-in-class services for helping customers find the perfect resorts based on their preferences



THE ASSIGNMENT

Your task is to **build interactive visuals and dashboards** to help Maveluxe's travel agents pick the best ski resorts for their customers based on their very picky tastes. We will build a dashboard that includes interactive maps and report cards for ski resorts around the world.



THE OBJECTIVES

- Use Pandas to read & manipulate multiple datasets
- Use Plotly to visualize data, communicate insights, and help users get the information they need
- Use Dash to add interactivity to the Plotly visuals, then build and deploy comprehensive dashboards



SETTING EXPECTATIONS



This course covers the **core functionality** for Plotly & Dash

- *We'll focus on adding interactivity to charts and constructing dashboard applications*



We'll focus on creating **interactive** visuals & dashboards

- *We will cover Plotly chart types enough to get you comfortable with them, but we won't dive into extreme customization. Instead, our focus is interactivity.*



We'll use **Jupyter Notebooks** as our primary coding environment

- *Jupyter Notebooks are free to use, and the industry standard for conducting data analysis with Python (we'll introduce Google Colab as an alternative, cloud-based environment as well)*



This course **requires previous knowledge** of Python and Pandas

- *It is strongly recommended that you complete the 3 previous courses in our Python specialist path, or have a solid understanding of base Python, DataFrame manipulation with Pandas, and visualization with Matplotlib or Seaborn*

INSTALLATION & SETUP



INSTALLING ANACONDA (MAC)

Installing
Anaconda

Launching
Jupyter

Google Colab

1) Go to anaconda.com/products/distribution and click

Download

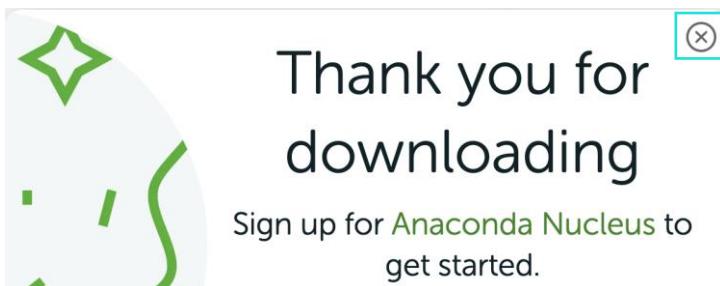
Individual Edition is now

ANACONDA DISTRIBUTION

The world's most popular open-source Python distribution platform



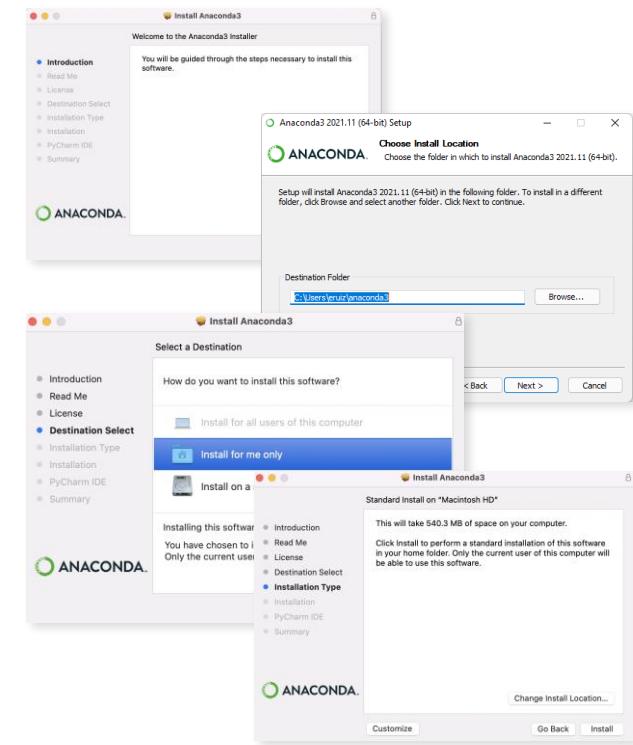
2) Click **X** on the Anaconda Nucleus pop-up
(no need to launch)



3) Launch the downloaded Anaconda **pkg** file

Anaconda3-202....pkg

4) Follow the **installation steps**
(default settings are OK)





INSTALLING ANACONDA (PC)

Installing
Anaconda

Launching
Jupyter

Google Colab

1) Go to anaconda.com/products/distribution and click

[Download](#)

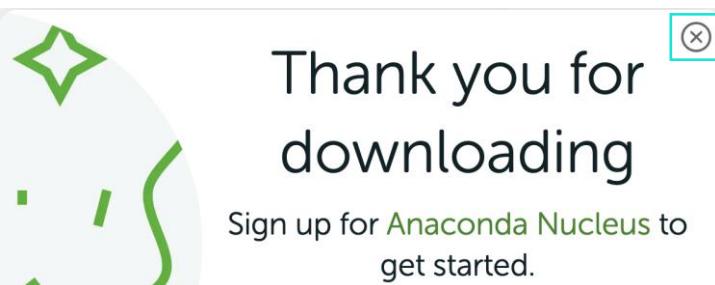
Individual Edition is now

ANACONDA DISTRIBUTION

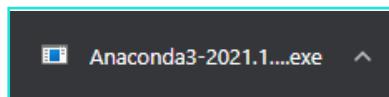
The world's most popular open-source Python distribution platform



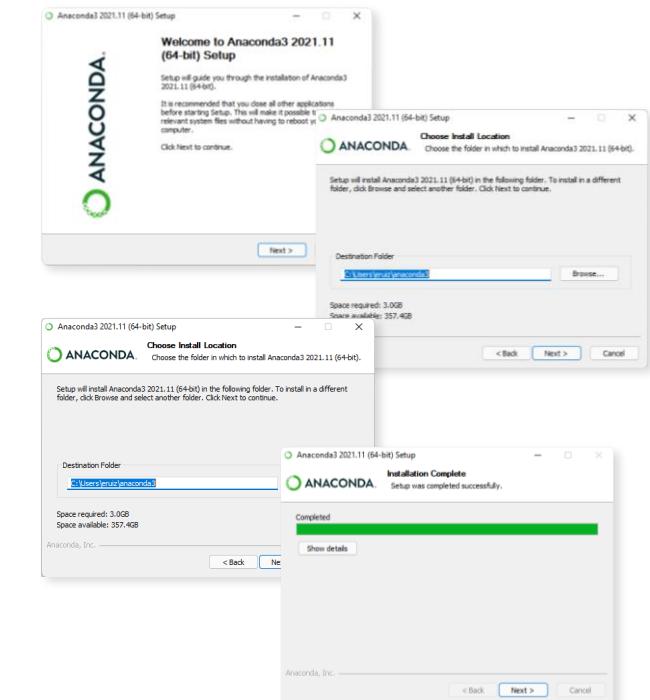
2) Click **X** on the Anaconda Nucleus pop-up
(no need to launch)



3) Launch the downloaded Anaconda **exe** file



4) Follow the **installation steps**
(default settings are OK)





LAUNCHING JUPYTER

1) Launch **Anaconda Navigator**

The screenshot shows the Anaconda Navigator application window. On the left, there's a sidebar with buttons for 'Home', 'Environments', 'Learning', and 'Community'. The main area is titled 'ANACONDA.NAVIGATOR' and shows a grid of applications. The 'Jupyter Notebook' application, located in the bottom right corner, is highlighted with a blue border. Its icon features a red circle with a white 'j' and the text 'jupyter Notebook 6.4.5'. Below the icon, it says 'Web-based, interactive computing notebook environment. Edit and run human-readable docs while describing the data analysis.' and has a 'Launch' button.

2) Find **Jupyter Notebook** and click **Launch**

Installing
Anaconda

Launching
Jupyter

Google Colab



YOUR FIRST JUPYTER NOTEBOOK

Installing
Anaconda

Launching
Jupyter

Google Colab

- Once inside the Jupyter interface, **create a folder** to store your notebooks for the course

The screenshot shows the Jupyter interface with the 'Files' tab selected. A context menu is open over a folder named 'Python 3 (ipykernel)'. The menu options include 'Upload', 'New', and a separator line, followed by 'Notebook:', 'Python 3 (ipykernel)', 'Other:', 'Text File', 'Folder', and 'Terminal'. The 'Folder' option is highlighted with a red arrow pointing from the left towards the right panel. The right panel displays a file tree with 'Documents' at the root, containing '..', 'Maven', and 'Untitled Folder'. 'Untitled Folder' is checked. A note at the bottom right says: 'NOTE: You can rename your folder by clicking "Rename" in the top left corner'.

- Open your new coursework folder and **launch your first Jupyter notebook!**

The screenshot shows the Jupyter interface with the 'Files' tab selected. A context menu is open over a folder named 'Python 3 (ipykernel)'. The menu options are the same as the previous screenshot. The 'Python 3 (ipykernel)' option is highlighted with a red arrow pointing from the left towards the right panel. The right panel shows the 'Untitled' notebook interface with a code cell labeled 'In []:'.

NOTE: You can rename your notebook by clicking on the title at the top of the screen



THE NOTEBOOK SERVER

Installing
Anaconda

Launching
Jupyter

Google Colab

NOTE: When you launch a Jupyter notebook, a terminal window may pop up as well; this is called a **notebook server**, and it powers the notebook interface

```
Last login: Tue Jan 25 14:04:12 on ttys002
(base) chrisb@Chriss-MBP ~ % jupyter notebook
[I 2022-01-26 08:45:53.886 LabApp] JupyterLab extension loaded from /Users/chrisb/opt/anaconda3/lib/python3.9/site-packages/jupyterlab
[I 2022-01-26 08:45:53.886 LabApp] JupyterLab application directory is /Users/chrisb/opt/anaconda3/share/jupyter/lab
[I 08:45:53.890 NotebookApp] Serving notebooks from local directory: /Users/chrisb
[I 08:45:53.890 NotebookApp] Jupyter Notebook 6.4.5 is running at:
[I 08:45:53.890 NotebookApp] http://localhost:8888/?token=3159cf032d9e6841d04910e257db2b24b6df6dfc878d6d5f
[I 08:45:53.890 NotebookApp] or http://127.0.0.1:8888/?token=3159cf032d9e6841d04910e257db2b24b6df6dfc878d6d5f
[I 08:45:53.890 NotebookApp] Use Control-C to stop this server and shut down all kernels (twice to skip confirmation).
[C 08:45:53.893 NotebookApp]

To access the notebook, open this file in a browser:
  file:///Users/chrisb/Library/Jupyter/runtime/nbserver-27175-open.html
Or copy and paste one of these URLs:
  http://localhost:8888/?token=3159cf032d9e6841d04910e257db2b24b6df6dfc878d6d5f
  or http://127.0.0.1:8888/?token=3159cf032d9e6841d04910e257db2b24b6df6dfc878d6d5f
[W 08:46:05.829 NotebookApp] Notebook Documents/Maven_Coursework/Python_Intro.ipynb
```



If you close the server window,
your notebooks will not run!

Depending on your OS, and method of launching Jupyter, one may not open. As long as you can run your notebooks, don't worry!



ALTERNATIVE: GOOGLE COLAB

Google Colab is Google's cloud-based version of Jupyter Notebooks

To create a Colab notebook:

1. Log in to a Gmail account
2. Go to colab.research.google.com
3. Click “new notebook”

Google Colab



Colab is very similar to Jupyter Notebooks (*they even share the same file extension*); the main difference is that you are connecting to **Google Drive** rather than your machine, so files will be stored in Google's cloud

The screenshot shows the Google Colab interface. At the top, there are tabs for 'Examples', 'Recent', 'Google Drive', 'GitHub', and 'Upload'. Below this is a search bar labeled 'Filter notebooks'. The 'Recent' tab is selected, showing two entries: 'Welcome To Colaboratory' (last opened 1:34 PM, first opened January 4) and 'Scratch_Work.ipynb' (January 25, January 4). Below this is a 'Drive' interface showing a file named '1_Python_Intro.ipynb' (You edited today) and a folder named 'Colab Notebooks'. A 'New notebook' button is highlighted with a blue border.

INTRO TO PLOTLY & DASH

INTRO TO PLOTLY & DASH



In this section we'll introduce the **Plotly** & **Dash** libraries, and cover the steps & key components for creating a basic Dash application with interactive Plotly visuals

TOPICS WE'LL COVER:

Why Interactivity?

The Plotly Ecosystem

Dash Applications

Layouts & Interactivity

Callback Functions

Application Run Options

Interactive Plotly Visuals

GOALS FOR THIS SECTION:

- Recognize the value of interactive charts & graphs
- Understand the anatomy of a Dash application, and the essential steps for creating one
- Learn to add interactive elements and process them with callback functions to update the app
- Create your first interactive visual with Plotly & Dash



WHY INTERACTIVITY?

Why
Interactivity?

The Plotly
Ecosystem

Dash
Applications

Layouts &
Interactivity

Callback
Functions

Application Run
Options

Interactive Plotly
Visuals

Adding **interactivity** to charts lets your stakeholders explore the data and conduct their own analysis, freeing up your time to tackle more problems

EXAMPLE

Visualizing store transactions over time (**static**)



"Can you build me a line chart showing transactions by store over time?"



"Great, now can you make another chart but zoom in for December 2013?"



"Thank you! What is the exact value for store 3 on Dec 3? I was also curious about 2015..."



"Sure thing!"



"Yeah, here you go."



"Uh..."



WHY INTERACTIVITY?

Why
Interactivity?

The Plotly
Ecosystem

Dash
Applications

Layouts &
Interactivity

Callback
Functions

Application Run
Options

Interactive Plotly
Visuals

Adding **interactivity** to charts lets your stakeholders explore the data and conduct their own analysis, freeing up your time to tackle more problems

EXAMPLE

Visualizing store transactions over time (**interactive**)



"Can you build me a line chart showing transactions by store over time?"



"Sure thing, I set up an interactive chart that allows you to zoom in on selected date periods and hover over each point for more detail!"



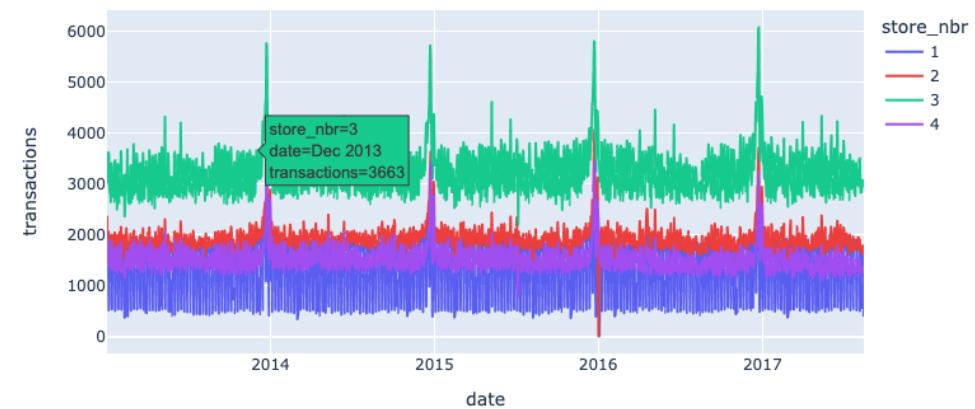
Adding **interactive elements** like dropdowns to filter data or tooltips to display metrics of interest can greatly improve the value of a single chart to its stakeholders

Select Date Range of Interest

02-Jan-13 → 15-Aug-17



Transactions by Store between 2013-01-02 and 2017-08-15





MEET PLOTLY & DASH

Why
Interactivity?

The Plotly
Ecosystem

Dash
Applications

Layouts &
Interactivity

Callback
Functions

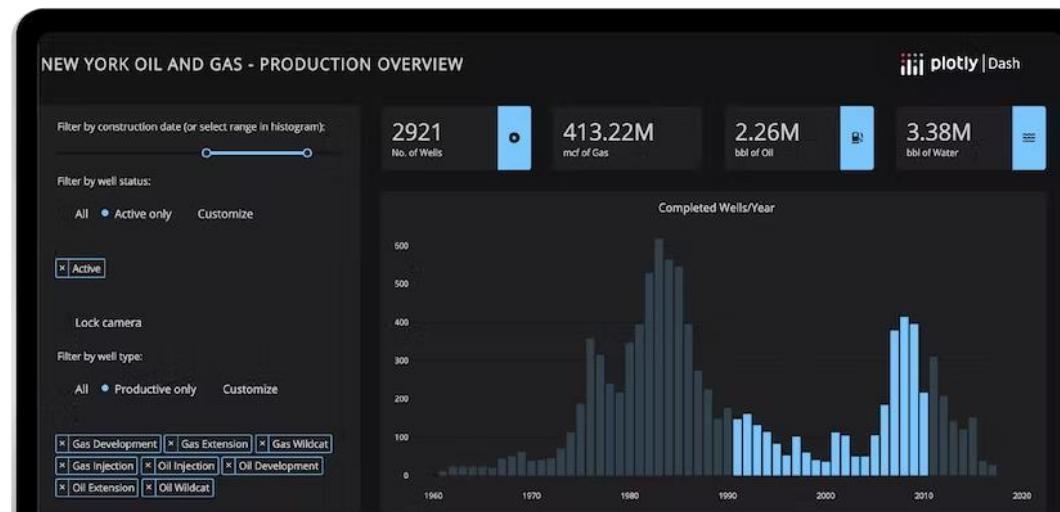
Application Run
Options

Interactive Plotly
Visuals



Plotly is an open-source JavaScript based library that focuses on creating interactive visualizations with the Python, R, or Julia programming languages

Dash is Plotly's sister library that focuses on building *dashboards* with Plotly visuals and deploying them as interactive web applications





INSTALLING PLOTLY & DASH

Why
Interactivity?

The Plotly
Ecosystem

Dash
Applications

Layouts &
Interactivity

Callback
Functions

Application Run
Options

Interactive Plotly
Visuals

1) Install plotly and dash via conda

```
import sys
!conda install --yes --prefix {sys.prefix} plotly
```

```
!conda install --yes --prefix {sys.prefix} dash
```

2) Install jupyter-dash via pip

This helps develop apps in Jupyter before Application Run

```
!pip install --prefix {sys.prefix} jupyter-dash
```



If you get a warning that “a new version of conda exists” during the installation, you can ignore it or run the code specified in the output



THE ANATOMY OF A DASH APPLICATION

Why
Interactivity?

The Plotly
Ecosystem

Dash
Applications

Layouts &
Interactivity

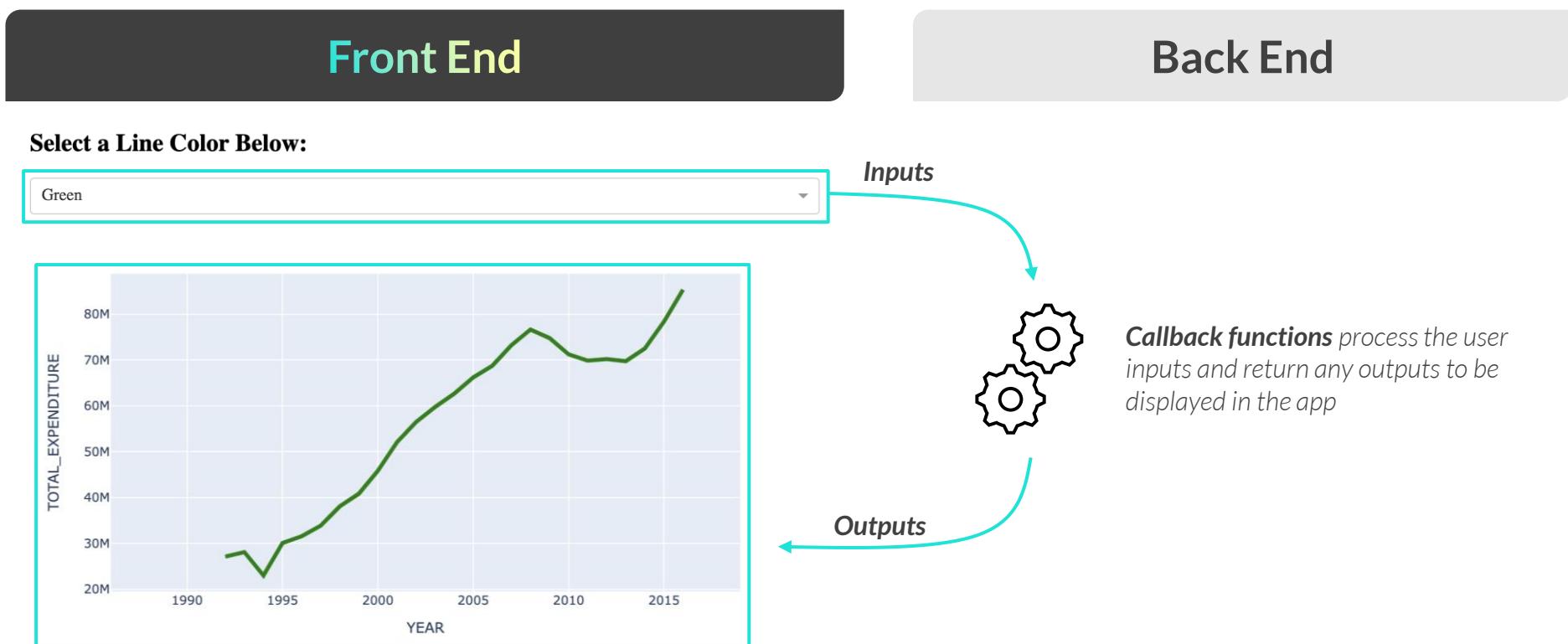
Callback
Functions

Application Run
Options

Interactive Plotly
Visuals

Dash applications are web apps with two main components:

- The **front end** displays interactive elements for user input (and any visuals affected by them)
- The **back end** processes the inputs and returns the outputs to be displayed in the visuals





CREATING A DASH APPLICATION

You can **create a dash application** by following these steps:

1

Import the
necessary libraries

2

Create the Dash
application

3

Set up the
HTML layout

4

Add the callback
functions

5

Run the
application

At this point you just have
an empty app

```
from dash import Dash, dcc, html
from dash.dependencies import Input, Output

app = Dash(__name__)

app.layout = html.Div([
    html.H2(), # HTML Header
    dcc.Dropdown(), # An Interactive Dropdown Menu
    dcc.Graph() # A Chart that changes based on Dropdown Menu Value
])

@app.callback(Output(), Input()) # Ties dropdown to chart
def interactive_chart(input): # Create a function accepts dropdown value as argument
    return output # Usually a Plotly chart

app.run_server(debug=True)
```

This is the **front end** of
the web application

This is the **back end** of
the web application

This **runs** the app!

Why
Interactivity?

The Plotly
Ecosystem

Dash
Applications

Layouts &
Interactivity

Callback
Functions

Application Run
Options

Interactive Plotly
Visuals



THE WORLD'S SIMPLEST DASH APP

Why
Interactivity?

The Plotly
Ecosystem

Dash
Applications

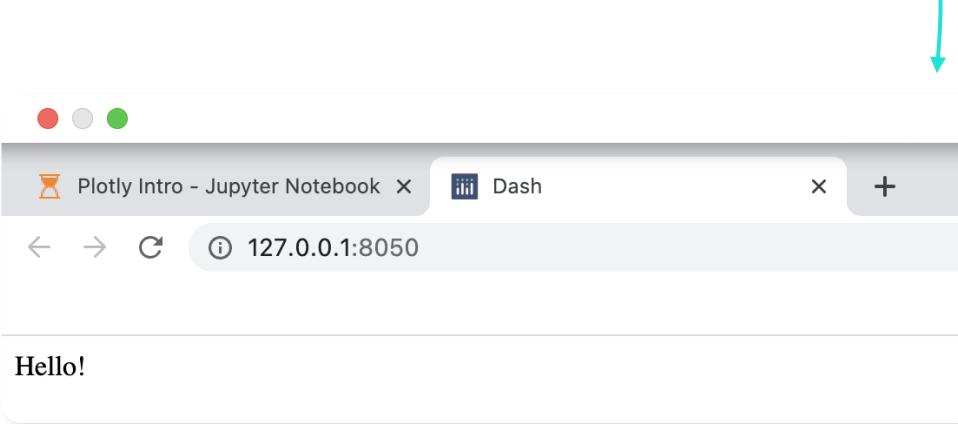
Layouts &
Interactivity

Callback
Functions

Application Run
Options

Interactive Plotly
Visuals

```
from dash import Dash, html  
  
app = Dash(__name__)  
  
app.layout = html.Div("Hello!")  
  
if __name__ == "__main__":  
    app.run_server()  
  
Dash is running on http://127.0.0.1:8050/
```



1. Import the Dash function and html module
2. Create the application with the Dash function
3. Add a single HTML element (div) with the text "Hello!"
4. Run the application on your local server



Dash applications **do not require callback functions** to run, but they are necessary for adding interactivity based on user inputs



Congrats, you just became
a Python web developer!



THE WORLD'S SIMPLEST DASH APP

Why
Interactivity?

The Plotly
Ecosystem

Dash
Applications

Layouts &
Interactivity

Callback
Functions

Application Run
Options

Interactive Plotly
Visuals

You can use JupyterDash to **run the app in-notebook** as you're designing it

```
from dash import html
from jupyter_dash import JupyterDash

app = JupyterDash(__name__)

app.layout = html.Div("Hello!")

if __name__ == "__main__":
    app.run_server(mode="inline")
```

- 1. Import the JupyterDash function instead of Dash
- 2. Create the application with the **JupyterDash** function
- 3. Add a single HTML element (div) with the text "Hello!"
- 4. Run the application **inside the Jupyter Notebook**, below the code cell (mode="inline")

Hello!



PRO TIP: Use JupyterDash to quickly and easily iterate on your app inside the notebook – you can switch to Dash for Application Run once it's finished (*more later!*)



IMPORTING LIBRARIES

Why
Interactivity?

The Plotly
Ecosystem

Dash
Applications

Layouts &
Interactivity

Callback
Functions

Application Run
Options

Interactive Plotly
Visuals

To build dashboards using Plotly & Dash, you may need to **import these libraries**:

```
from dash import Dash, html, dcc
from dash.dependencies import Output, Input
from jupyter_dash import JupyterDash
import plotly.express as px
import pandas as pd
```

Functions for creating the app and adding elements

Back-end functions for adding interactivity

Function for creating & running the app in Jupyter Notebooks

Library for data prep & ETL

Library for adding Plotly visuals



Importing specific functions and modules from dash instead of the full library helps when writing the code, as you don't need to reference the library when calling each function



CREATING THE APP

Why
Interactivity?

The Plotly
Ecosystem

Dash
Applications

Layouts &
Interactivity

Callback
Functions

Application Run
Options

Interactive Plotly
Visuals

The Dash(_name_) function **creates a Dash application**

- This is typically assigned to a variable called “app”

```
import dash  
  
app = dash.Dash(__name__)  
  
app
```

Note that importing the entire dash library requires calling it before the Dash(_name_) function

`<dash.dash.Dash at 0x7feeeb9a8c40>` This is a *Dash application* object



name is a special variable used to only run a Dash app if the script is being run directly (not being imported as a module)



HTML LAYOUTS

Why
Interactivity?

The Plotly
Ecosystem

Dash
Applications

Layouts &
Interactivity

Callback
Functions

Application Run
Options

Interactive Plotly
Visuals

Dash uses **HTML layouts** for designing the front-end of the application

- Use the **html** module to specify the visual components and assign it to **app.layout**

```
from jupyter_dash import JupyterDash
from dash import html

app = JupyterDash(__name__)

app.layout = html.Div("Hello!")

if __name__ == "__main__":
    app.run_server(mode="inline")
```

The **.Div()** method lets you add **html** sections to store different components

Hello!



Familiarity with the **HTML** and **CSS** web design languages can be a big help for making beautiful applications – we will conduct a brief crash course on the basics later!



INTERACTIVE ELEMENTS

Why
Interactivity?

The Plotly
Ecosystem

Dash
Applications

Layouts &
Interactivity

Callback
Functions

Application Run
Options

Interactive Plotly
Visuals

Dash has many **interactive elements** that can be added to apps for user input

- These are provided by the Dash Core Components module (dcc)

Interactive Element	Description
Dropdown	Single or multi-select dropdown list of pre-defined options
Slider	Slider for selecting a single value from a pre-defined list
RangeSlider	Slider for selecting a range of values from a pre-defined list
Checklist	Multi-select checkboxes from a pre-defined list
RadioItems	Single-select radio buttons from a pre-defined list
DatePickerSingle	Dropdown calendar to select a single date
DatePickerRange	Dropdown calendar to select a date range
Tabs	Tabs for navigating to different views of the app
Graphs	Container for Plotly figures



These interactive elements
are useless until they are
processed in the back-end
with **callback functions**



INTERACTIVE ELEMENTS

Why
Interactivity?

The Plotly
Ecosystem

Dash
Applications

Layouts &
Interactivity

Callback
Functions

Application Run
Options

Interactive Plotly
Visuals

Dash has many **interactive elements** that can be added to apps for user input

- These are provided by the Dash Core Components module (dcc)

EXAMPLE

Adding a dropdown color-picker

```
app = JupyterDash(__name__)

app.layout = html.Div([
    "Pick a Color!",
    dcc.Dropdown(
        options=[ "Red", "Green", "Blue" ],
        id="color-input",
        value="Red"
    ),
]

if __name__ == "__main__":
    app.run_server(mode="inline")
```



→ This **dcc.Dropdown()** component has three properties:

1. **options**: contains the contents of the dropdown
 - This is a list of strings that populate the dropdown menu
 - The option selected by the user gets passed through the value
 - It is possible to have a user facing label that differs from the value processed in the backend (more later!)
2. **id**: the identifier for the value passed through
 - This helps tie input values to outputs in the app (like charts!)
3. **value**: the option selected
 - This helps set a default “starting” value if needed
 - This property changes whenever a user selects a new option



CALLBACK FUNCTIONS

Why
Interactivity?

The Plotly
Ecosystem

Dash
Applications

Layouts &
Interactivity

Callback
Functions

Application Run
Options

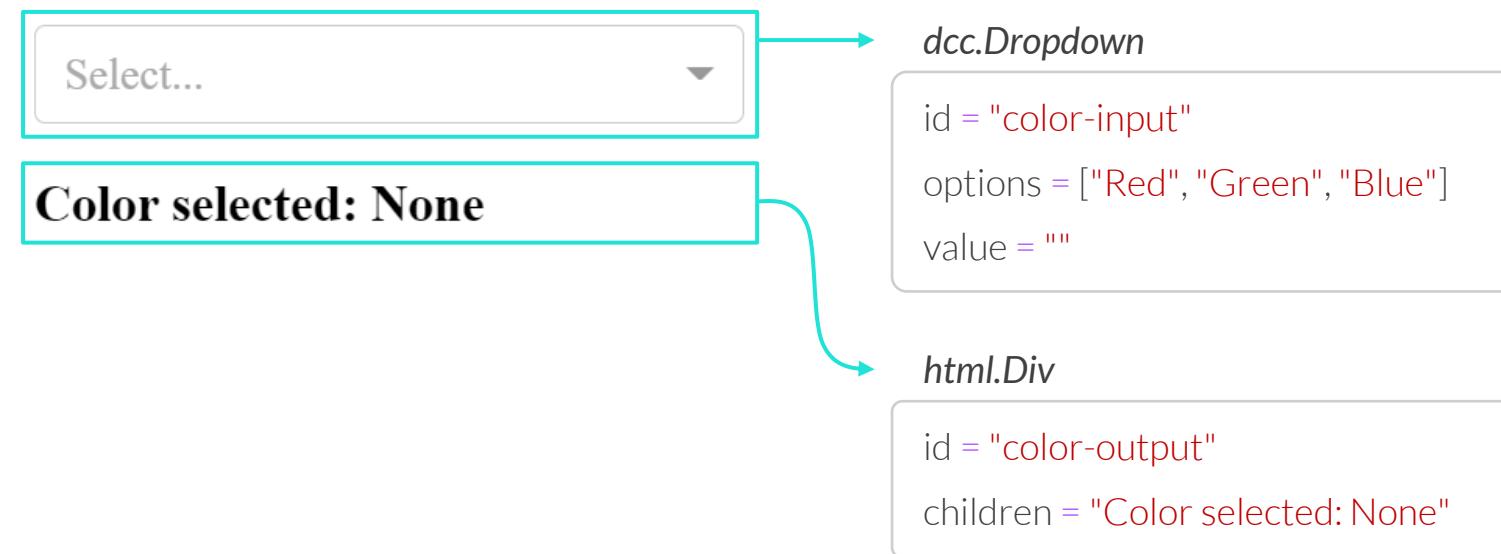
Interactive Plotly
Visuals

Callback functions process user inputs and update the app accordingly

- They are triggered by a change to a property of an HTML component (*input*)
- They then change the property of another HTML component (*output*)

EXAMPLE

Adding a dropdown color-picker





CALLBACK FUNCTIONS

Why
Interactivity?

The Plotly
Ecosystem

Dash
Applications

Layouts &
Interactivity

Callback
Functions

Application Run
Options

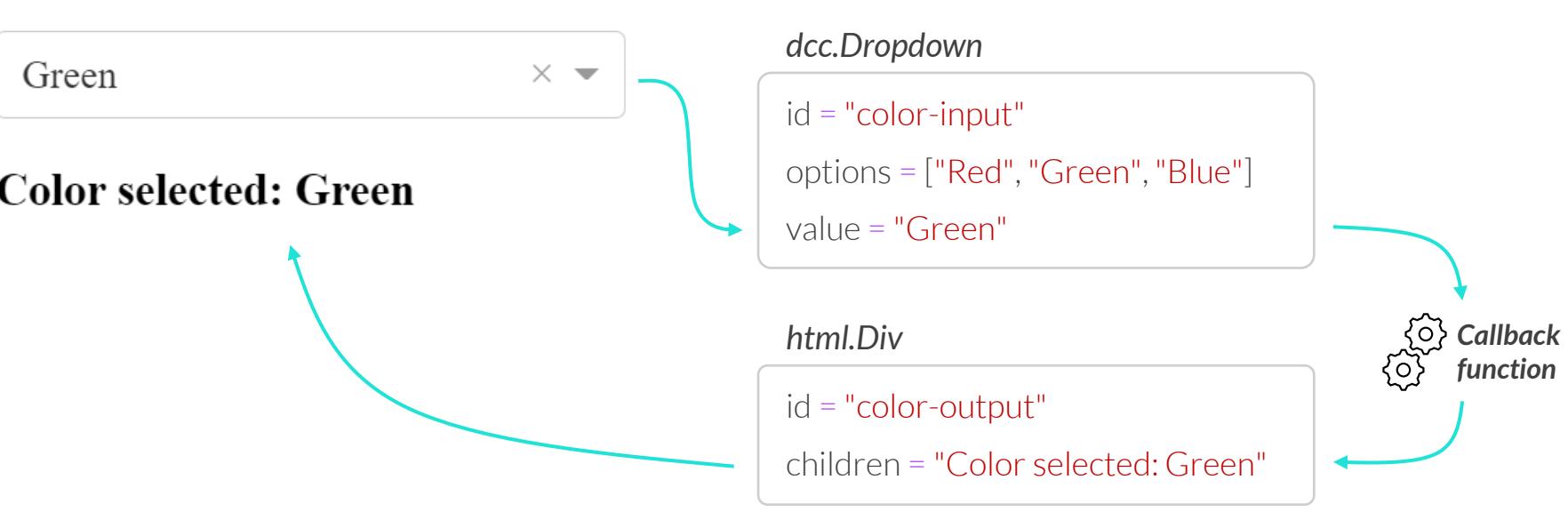
Interactive Plotly
Visuals

Callback functions process user inputs and update the app accordingly

- They are triggered by a change to a property of an HTML component (*input*)
- They then change the property of another HTML component (*output*)

EXAMPLE

Adding a dropdown color-picker





CALLBACK FUNCTIONS

Why
Interactivity?

The Plotly
Ecosystem

Dash
Applications

Layouts &
Interactivity

Callback
Functions

Application Run
Options

Interactive Plotly
Visuals

Callback functions are defined by using the **@app.callback** decorator and have at least two arguments (*Output & Input*), followed by the function itself

```
@app.callback(  
    Output(component_id, component_property),  
    Input(component_id, component_property))
```

*The Input & Output
arguments of the
callback decorator
(Output goes first!)*

*The id of the html component that
triggers (input) or gets modified by
(output) the callback function*

*The property of the html component that
is passed into (input) or gets modified by
(output) the callback function*

Examples:

- “**children**” (for text)
- “**value**” (for interactive elements)
- “**figure**” (for charts)



CALLBACK FUNCTIONS

Why
Interactivity?

The Plotly
Ecosystem

Dash
Applications

Layouts &
Interactivity

Callback
Functions

Application Run
Options

Interactive Plotly
Visuals

Callback functions are defined by using the **@app.callback** decorator and have at least two arguments (*Output & Input*), followed by the function itself

```
@app.callback(  
    Output(component_id, component_property),  
    Input(component_id, component_property)  
)  
def function_name(variable):  
    #function steps  
    return f"Output: {variable}"
```

Defines the callback function and assigns the value from the property of the input component to a variable

New value for the property of the output component



CALLBACK FUNCTIONS

Why
Interactivity?

The Plotly
Ecosystem

Dash
Applications

Layouts &
Interactivity

Callback
Functions

Application Run
Options

Interactive Plotly
Visuals

Callback functions are defined by using the **@app.callback** decorator and have at least two arguments (*Output* & *Input*), followed by the function itself

EXAMPLE

Adding a dropdown color-picker

```
app.layout = html.Div(  
    [dcc.Dropdown(  
        options=["Red", "Green", "Blue"],  
        id="color-input",  
    ),  
     html.Div(id="color-output"),  
])  
  
@app.callback(Output("color-output", "children"), Input("color-input", "value"))  
def update_output_div(color):  
    return f"Color Selected: {color}"
```

The function must immediately follow the @app.callback decorator

Note that the "value" and "children" properties aren't specified when creating the components

This callback function is triggered when the "value" property of the "color-input" component changes, which updates the "children" property of the "color-output" component



PREVENTING UPDATES

Why
Interactivity?

The Plotly
Ecosystem

Dash
Applications

Layouts &
Interactivity

Callback
Functions

Application Run
Options

Interactive Plotly
Visuals

Callback functions run as soon as the app launches by default, but you can add logic to **prevent updates**

- This can help avoid errors when interactive elements are in an “empty state”

```
@app.callback(Output("color-output", "children"), Input("color-input", "value"))
def update_output_div(color):
    return f"Color Selected: {color}"
```



Select... ▾
Color Selected: None

} Since the dropdown component has no “value” selected when launching the app, “None” gets passed into the callback function and output text

```
@app.callback(Output("color-output", "children"), Input("color-input", "value"))
def update_output_div(color):
    if not color:
        raise PreventUpdate
    return f"Color Selected: {color}"
```



Select... ▾

} This raises a **PreventUpdate** exception if the input is “None” which prevents the app from displaying any output text upon launch



APPLICATION RUN OPTIONS

Why
Interactivity?

The Plotly
Ecosystem

Dash
Applications

Layouts &
Interactivity

Callback
Functions

Application Run
Options

Interactive Plotly
Visuals

There are several **Application Run options** you can use when running the app:

- **debug=True**: helps with troubleshooting during development (*i.e.*, better error messages)
- **host/port**: specify the server address of the app – the default is: `http://127.0.0.1:8050/`
- **mode="inline"**: runs the app in-notebook when using JupyterDash (*not an option in Dash*)
- **height/width**: set the height or width of the app in pixels or a percentage

```
if __name__ == "__main__":
    app.run_server(debug=True, host="0.0.0.0", port=8051, mode="inline", height=800, width="80%")
```



PRO TIP: The host/port options become more important when deploying your application; and setting width as a percentage is a great way to keep your app proportions consistent!

ASSIGNMENT: SIMPLE DASH APP



NEW MESSAGE

March 3, 2023

From: **Ernie Educator** (Teacher & Friend)
Subject: **Favor?**

Hey ol' buddy, ol' pal,

Did you catch the game yesterday? Crazy...

Anyways, last time we were together you mentioned you could build dashboards without paid software, and I was wondering if you could help me with a project for my blog. I am passionate about education and want to help others understand data on education funding – could you build a simple app that we can fill in together?

Thanks!

📎 section01_assignments.ipynb

Reply

Forward

Results Preview

Select a State to Analyze:

Oregon



State Selected: Oregon

SOLUTION: SIMPLE DASH APP

 NEW MESSAGE

March 3, 2023

From: Ernie Educator (Teacher & Friend)

Subject: Favor?

Hey ol' buddy, ol' pal,

Did you catch the game yesterday? Crazy...

Anyways, last time we were together you mentioned you could build dashboards without paid software., and I was wondering if you could help me with a project for my blog. I am passionate about education and want to help others understand data on education funding – could you build a simple app that we can fill in together?

Thanks!

 section01_solutions.ipynb

Solution Code

```
from dash import html, dcc
from dash.dependencies import Output, Input
from jupyter_dash import JupyterDash
from dash.exceptions import PreventUpdate

app = JupyterDash(__name__)

app.layout = html.Div(
    ["Select a State to Analyze: ",
     dcc.Dropdown(
         id="State Dropdown",
         options=["California", "Oregon", "Washington"]
     ),
     html.Div(id="text-output")
])

@app.callback(
    Output("text-output", "children"),
    Input("State Dropdown", "value")
)
def update_output_div(state):
    if not state:
        raise PreventUpdate
    return f"State Selected: {state}"

if __name__ == "__main__":
    app.run_server(mode="inline", debug=True)
```



INTERACTIVE PLOTLY VISUALS

Why
Interactivity?

The Plotly
Ecosystem

Dash
Applications

Layouts &
Interactivity

Callback
Functions

Application Run
Options

Interactive Plotly
Visuals

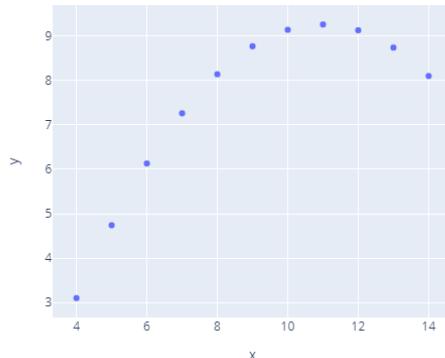
You can add **interactive Plotly visuals** to Dash apps with these 3 steps:

1. Create a “prototype” visual using Pandas & Plotly without interactivity
2. Identify the element that changes and define its options in the interactive component
3. Connect the interactive component to the visual using a callback function

EXAMPLE

Visualizing the different datasets from Anscombe's Quartet

Anscombe's Quartet



Create one “view” of the visual
as if you had interacted with it

Select...

I

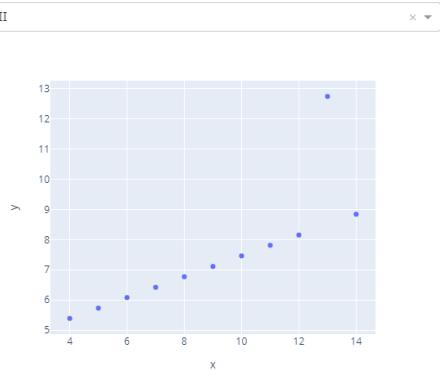
II

III

IV

Use the values for the different
“views” as the interactive options

Anscombe's Quartet



Create the chart in the callback
function to bring it all together



INTERACTIVE PLOTLY VISUALS

Why
Interactivity?

The Plotly
Ecosystem

Dash
Applications

Layouts &
Interactivity

Callback
Functions

Application Run
Options

Interactive Plotly
Visuals

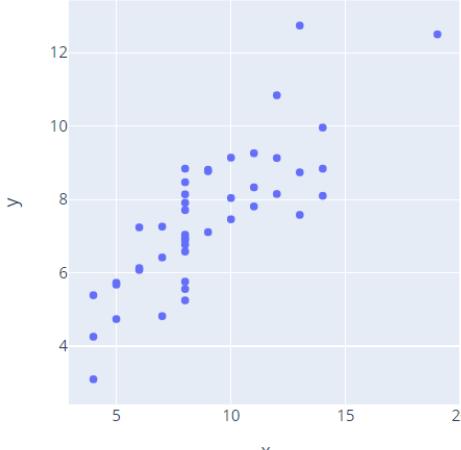
STEP 1

Create a “prototype” visual using Pandas & Plotly without interactivity

```
df.head()
```

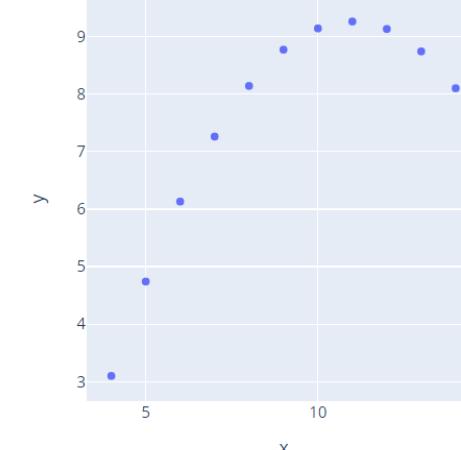
dataset	x	y
0	10.0	8.04
1	8.0	6.95
2	13.0	7.58
3	9.0	8.81
4	11.0	8.33

```
px.scatter(df, x="x", y="y")
```



Anscombe's quartet is a group of four datasets with nearly identical regression lines but significantly different visual relationships

```
px.scatter(df.loc[df["dataset"] == "II"], x="x", y="y")
```



You can use Plotly Express and the **px.scatter** function to plot the “x” and “y” columns in the DataFrame

Note that this plots all four datasets in Anscombe's quartet

This will be the element that the user can change to filter the chart!



INTERACTIVE PLOTLY VISUALS

Why
Interactivity?

The Plotly
Ecosystem

Dash
Applications

Layouts &
Interactivity

Callback
Functions

Application Run
Options

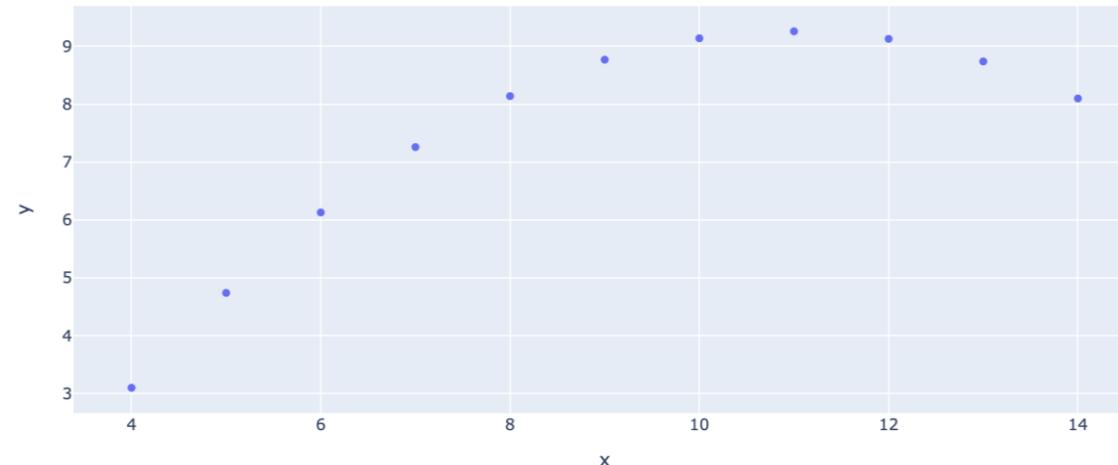
Interactive Plotly
Visuals

STEP 1

Create a “prototype” visual using Pandas & Plotly without interactivity

```
app.layout = html.Div([
    html.H3("Anscombe's Quartet"),
    dcc.Graph(
        id="visual",
        figure=px.scatter(df.loc[df["dataset"]=="II"], x="x", y="y")
    )
])
```

Anscombe's Quartet



You can add a Plotly visual to your app with the **figure** property of the **dcc.Graph** component



INTERACTIVE PLOTLY VISUALS

Why
Interactivity?

The Plotly
Ecosystem

Dash
Applications

Layouts &
Interactivity

Callback
Functions

Application Run
Options

Interactive Plotly
Visuals

STEP 2

Identify the element that changes and define its options in the interactive component

```
app.layout = html.Div([
    html.H3("Anscombe's Quartet"),
    dcc.Dropdown(id="dropdown", options=df["dataset"].unique()),
    dcc.Graph(
        id="visual",
        figure = px.scatter(
            df.query(f"dataset == 'II'"),
            x="x",
            y="y"
        )
    )
])
```

Anscombe's Quartet



You can use the `.unique()` method to grab all possible values in a column to populate your dropdown

This will let the user select from the possible values to filter the visual by

Note that the dropdown and the visual are not connected yet!



INTERACTIVE PLOTLY VISUALS

Why
Interactivity?

The Plotly
Ecosystem

Dash
Applications

Layouts &
Interactivity

Callback
Functions

Application Run
Options

Interactive Plotly
Visuals

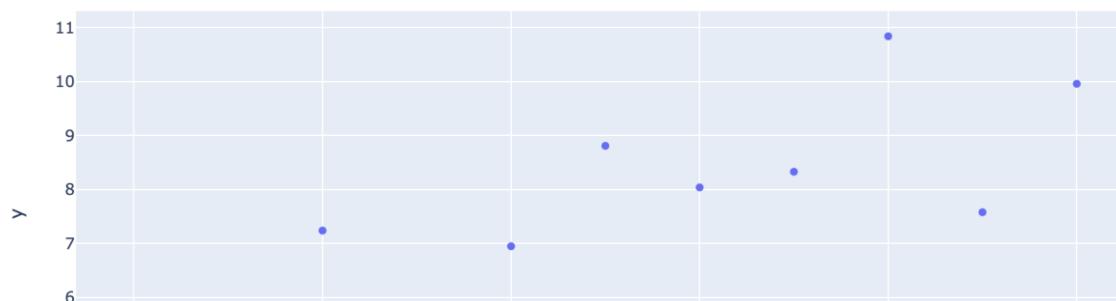
STEP 3

Connect the interactive component to the visual using a callback function

```
app.layout = html.Div([
    html.H3("Anscombe's Quartet"),
    dcc.Dropdown(id="dropdown", options = list(df["dataset"].unique())),
    dcc.Graph(id="visual")
])

@app.callback(Output("visual", "figure"), Input("dropdown", "value"))
def interactive_visual(selection):
    fig=px.scatter(
        df.query(f"dataset == '{selection}'"),
        x="x",
        y="y"
    )
    return fig
```

Anscombe's Quartet



This uses the value in the dropdown to filter the DataFrame to be plotted, then updates the "figure" property of the graph to show the updated visual

Note that the plot is only created in the callback function and doesn't need to be declared inside the `dcc.Graph` component

ASSIGNMENT: A MORE REALISTIC DASH APP

 **NEW MESSAGE**
March 3, 2023

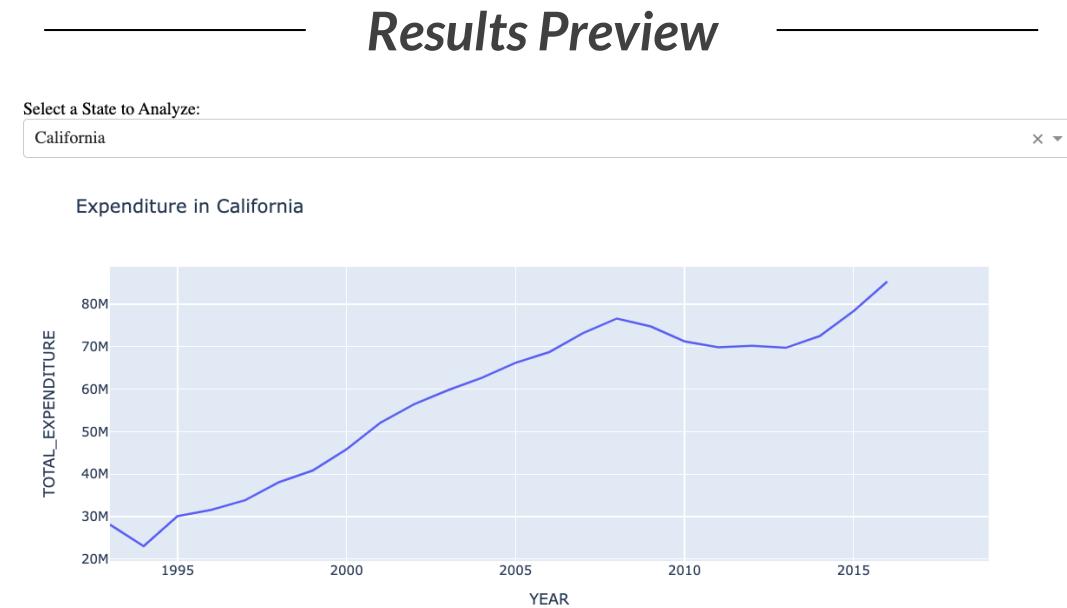
From: Ernie Educator (Teacher & Friend)
Subject: Embedding a Chart?

Hey,

Cool application! I have a bit of Python knowledge, so I went ahead and prototyped a line chart that I'd like embedded in the application based on the state selected to analyze. Can you update the application? You can remove the html text output.

Thanks!

 section01_assignments.ipynb  



SOLUTION: A MORE REALISTIC DASH APP

 NEW MESSAGE
March 3, 2023

From: Ernie Educator (Teacher & Friend)
Subject: Embedding a Chart?

Hey,

Cool application! I have a bit of Python knowledge, so I went ahead and prototyped a line chart that I'd like embedded in the application based on the state selected to analyze. Can you update the application? You can remove the html text output.

Thanks!

 section01_solutions.ipynb  Reply  Forward

Solution Code

```
app.layout = html.Div(
    [ "Select a State to Analyze: ",
      dcc.Dropdown(
          id="State Dropdown",
          options=[ "California", "Oregon", "Washington" ]
      ),
      dcc.Graph(id="graph")
    ])

@app.callback(Output("graph", "figure"), Input("State Dropdown", "value"))
def update_output_div(state):
    if not state:
        raise PreventUpdate
    df = education.query(f"STATE == '{state.upper()}' & YEAR > 1992")
    fig = px.line(
        df,
        x="YEAR",
        y="TOTAL_EXPENDITURE",
        title=f"Expenditure in {state.title()}"
    )
    return fig
```

KEY TAKEAWAYS



Plotly & Dash are Python libraries for creating **interactive visuals**

- *Plotly lets you build charts and Dash lets you interact with them by deploying them as web applications*



Dash applications have two main components: a **front-end** & **back-end**

- *The front-end is the HTML layout that displays any text, interactive elements, and visuals*
- *The back-end ties the interactive elements and visuals together by using callback functions*



Callback functions look for user “inputs” to update “outputs” accordingly

- *Each input and output is associated with a component id and property*



Pandas is key for manipulating the data you want to visualize

- *Plotly charts are built using Pandas DataFrames, and their interactivity often relies on sorting & filtering them*

PLOTLY CHARTS

PLOTLY CHARTS



In this section we'll dive into the **Plotly** library and use it to build & customize several chart types, including line charts, bar charts, pie charts, scatterplots, histograms, and maps

TOPICS WE'LL COVER:

Plotly Figures

Basic Charts

Chart Formatting

Map Visuals

GOALS FOR THIS SECTION:

- Understand the difference between the Plotly Graph Objects and Plotly Express plotting methods
- Create basic charts using Plotly Express functions
- Customize Plotly Express charts using update methods
- Create map-based visuals using geographic data



PLOTLY FIGURES

Plotly Figures

Basic Charts

Chart Formatting

Map Visuals

Plotly figures are created by drawing “traces” on top of a blank canvas

There are two methods for creating them:

Plotly Graph Objects

Charts are created by defining a figure object, and traces are customized using figure methods

```
fig = go.Figure()

fig.add_scatter(
    x=anscombe.loc[anscombe["Dataset"]=="I", "x"],
    y=anscombe.loc[anscombe["Dataset"]=="I", "y"],
    mode="markers",
    name="I"
)

fig.add_scatter(
    x=anscombe.loc[anscombe["Dataset"]=="II", "x"],
    y=anscombe.loc[anscombe["Dataset"]=="II", "y"],
    mode="markers",
    name="II"
)

fig.layout.title = "Anscombe Datasets I & II"
fig.layout.legend.title = "Dataset"
fig.layout.xaxis.title = "X"
fig.layout.yaxis.title = "Y"

fig.show()
```

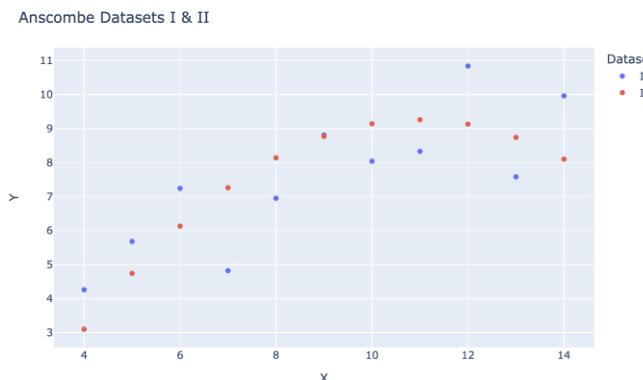
Plotly Express

Charts are created with Plotly Express functions, with most customization options built in

```
px.scatter(
    anscombe.query("Dataset in ['I', 'II']"),
    x="x",
    y="y",
    color="Dataset",
    title="Anscombe Datasets I & II"
)
```



We'll focus on **Plotly Express**, as it's easier to work with and provides most of the options





BASIC CHARTS

Plotly Figures

Basic Charts

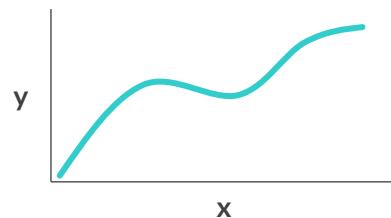
Chart Formatting

Map Visuals

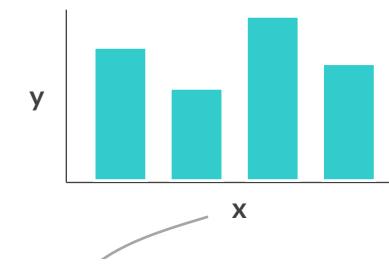
You can create these **basic charts** with Plotly Express by using these functions

- You simply need to select a DataFrame as the first argument and specify the DataFrame columns to plot for the rest of the arguments (*just be mindful of data types!*)

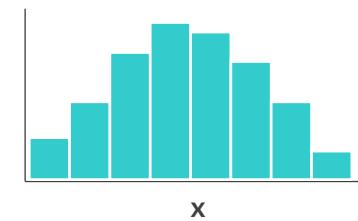
`px.line(df, x="", y="")`



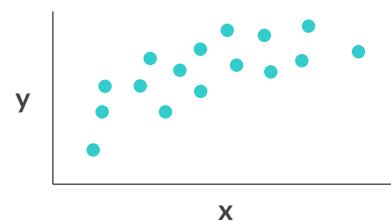
`px.bar(df, x="", y="")`



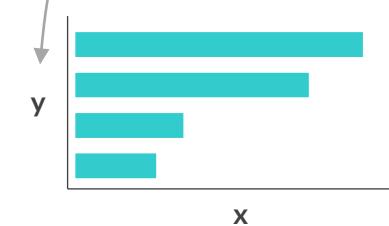
`px.histogram(df, x="")`



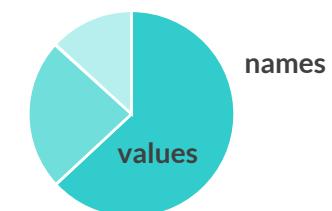
`px.scatter(df, x="", y="")`



Just swap the columns!



`px.pie(df, values="", names "")`





BASIC CHARTS

Plotly Figures

Basic Charts

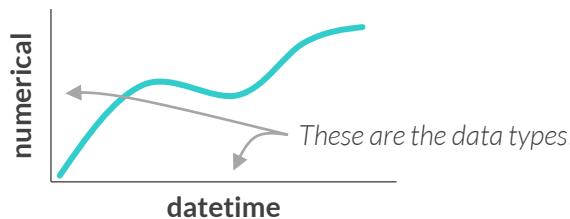
Chart Formatting

Map Visuals

You can create these **basic charts** with Plotly Express by using these functions

- You simply need to select a DataFrame as the first argument and specify the DataFrame columns to plot for the rest of the arguments (*just be mindful of data types!*)

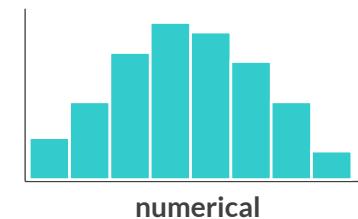
`px.line(df, x="", y="")`



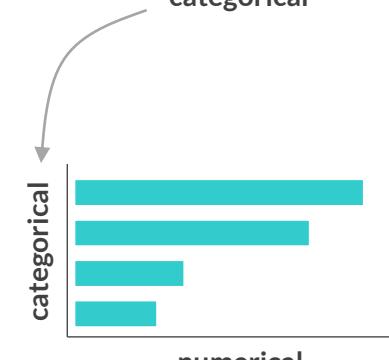
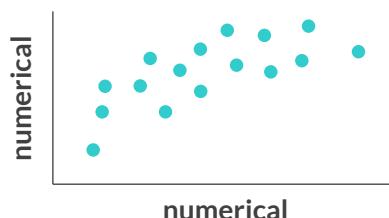
`px.bar(df, x="", y="")`



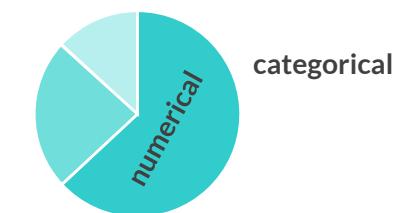
`px.histogram(df, x="")`



`px.scatter(df, x="", y="")`



`px.pie(df, values="", names "")`



ASSIGNMENT: LINE CHARTS

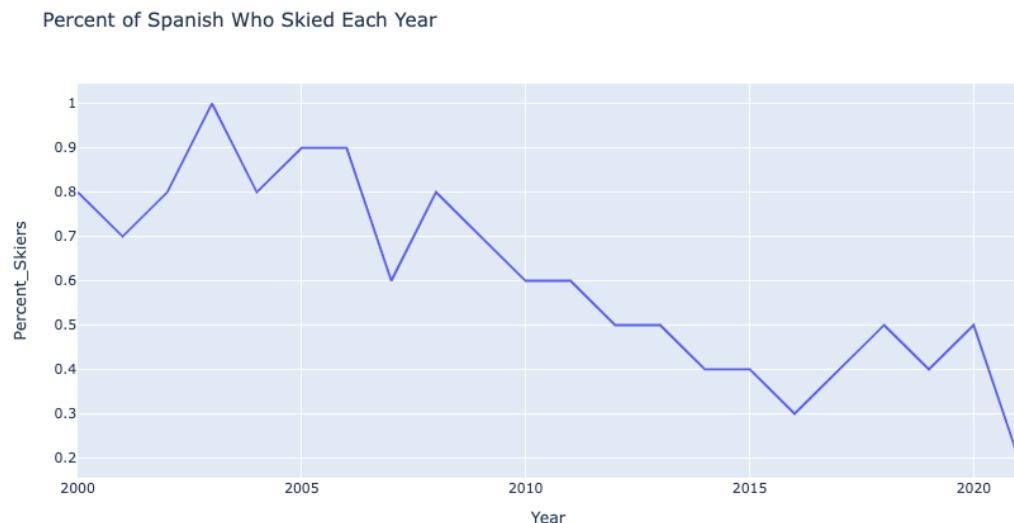
 NEW MESSAGE
March 7, 2023

From: Leonard Lift (Ski Trip Concierge)
Subject: Info for Client

Hey there,
I have a very “challenging” client who is asking me a million questions about European Ski Resorts.
Apparently, they went to Spain for a ski trip in the Pyrenees two decades ago and said it was way too crowded.
Can you look at the Spanish ski data and see if skiing is still as popular in Spain as it was back then?
Thanks!

Results Preview



SOLUTION: LINE CHARTS

 NEW MESSAGE
March 7, 2023

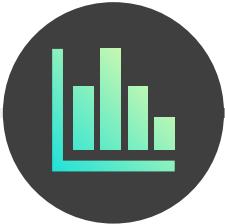
From: Leonard Lift (Ski Trip Concierge)
Subject: Info for Client

Hey there,
I have a very “challenging” client who is asking me a million questions about European Ski Resorts.
Apparently, they went to Spain for a ski trip in the Pyrenees two decades ago and said it was way too crowded.
Can you look at the Spanish ski data and see if skiing is still as popular in Spain as it was back then?
Thanks!

 section02_solutions.ipynb  Reply  Forward

Solution Code

```
px.line(  
    spain_skiers,  
    "Year",  
    "Percent_Skiers",  
    title="Percent of Spanish Who Skied Each Year")
```



MULTIPLE SERIES

Plotly Figures

Basic Charts

Chart Formatting

Map Visuals

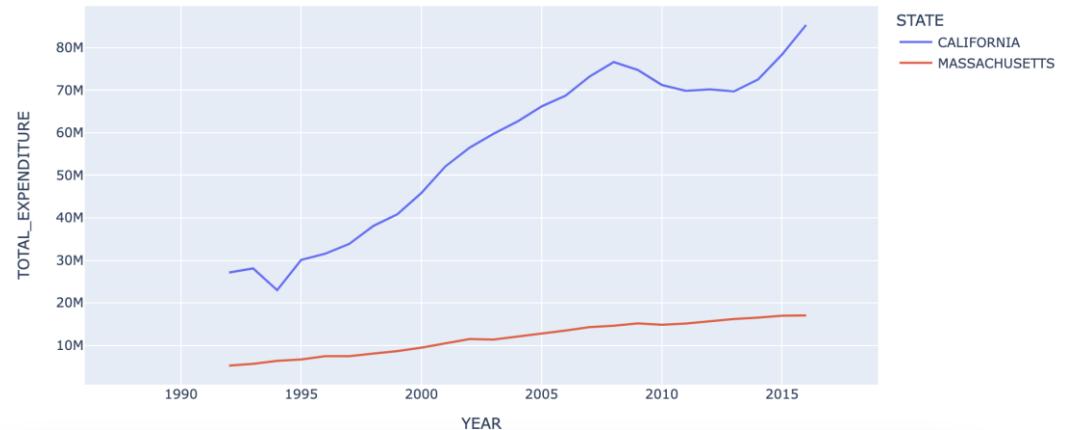
You can plot **multiple series** by using the “color” argument on most chart types

```
education.head()
```

	STATE	YEAR	TOTAL_EXPENDITURE
0	ALABAMA	1992	2653798.0
1	ALASKA	1992	972488.0
2	ARIZONA	1992	3401580.0
3	ARKANSAS	1992	1743022.0
4	CALIFORNIA	1992	27138832.0

```
px.line(  
    education.query("STATE in ['CALIFORNIA', 'MASSACHUSETTS']"),  
    x="YEAR",  
    y="TOTAL_EXPENDITURE",  
    color="STATE",  
    title="Education Spend in California vs. Massachusetts"  
)
```

Education Spend in California vs. Massachusetts





MULTIPLE SERIES

Plotly Figures

Basic Charts

Chart Formatting

Map Visuals

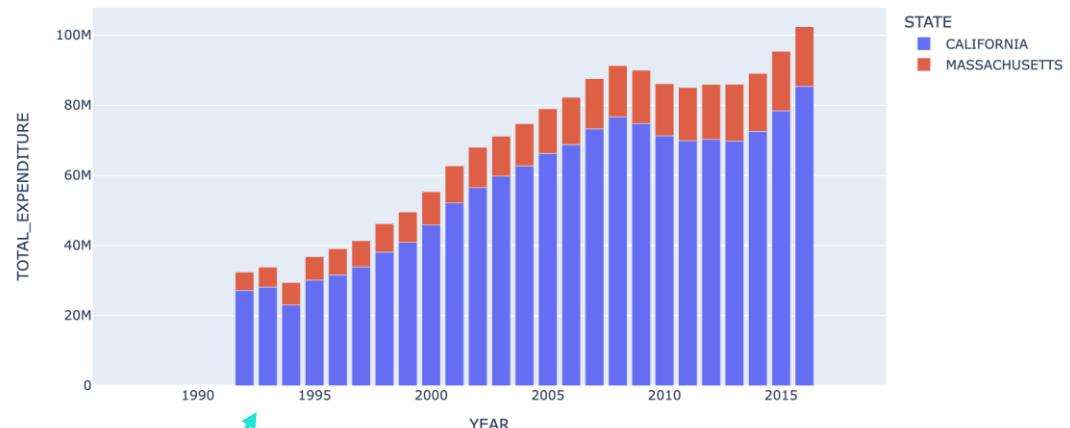
You can plot **multiple series** by using the “color” argument on most chart types

```
education.head()
```

	STATE	YEAR	TOTAL_EXPENDITURE
0	ALABAMA	1992	2653798.0
1	ALASKA	1992	972488.0
2	ARIZONA	1992	3401580.0
3	ARKANSAS	1992	1743022.0
4	CALIFORNIA	1992	27138832.0

```
px.bar(  
    education.query("STATE in ['CALIFORNIA', 'MASSACHUSETTS']"),  
    x="YEAR",  
    y="TOTAL_EXPENDITURE",  
    color="STATE",  
    title="Education Spend in California vs. Massachusetts"  
)
```

Education Spend in California vs. Massachusetts



Bars are stacked by default!



PRO TIP: GROUPED BAR CHARTS

Plotly Figures

Basic Charts

Chart Formatting

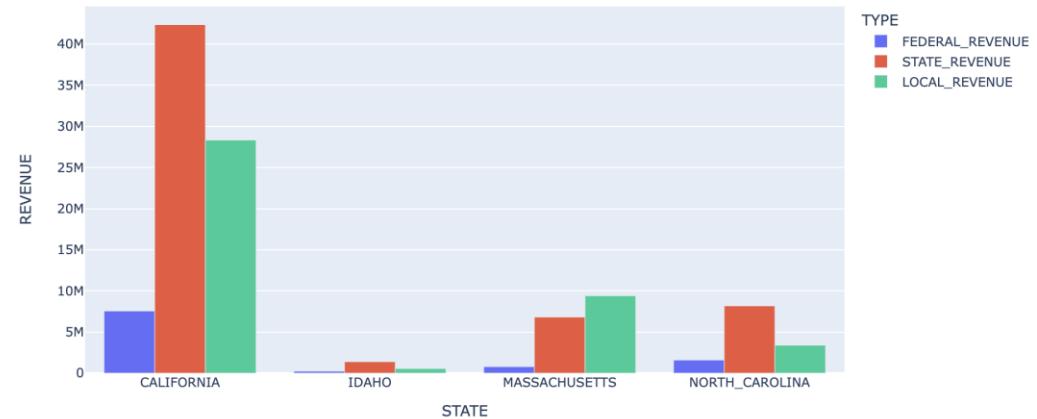
Map Visuals

revenue

	STATE	TYPE	REVENUE
4	CALIFORNIA	FEDERAL_REVENUE	7556365.0
12	IDAHO	FEDERAL_REVENUE	232449.0
21	MASSACHUSETTS	FEDERAL_REVENUE	778939.0
33	NORTH_CAROLINA	FEDERAL_REVENUE	1589570.0
57	CALIFORNIA	STATE_REVENUE	42360470.0
65	IDAHO	STATE_REVENUE	1381205.0
74	MASSACHUSETTS	STATE_REVENUE	6808436.0
86	NORTH_CAROLINA	STATE_REVENUE	8172685.0
110	CALIFORNIA	LOCAL_REVENUE	28331207.0
118	IDAHO	LOCAL_REVENUE	554313.0
127	MASSACHUSETTS	LOCAL_REVENUE	9397810.0
139	NORTH_CAROLINA	LOCAL_REVENUE	3384679.0

```
px.bar(  
    revenue,  
    x="STATE",  
    y="REVENUE",  
    color="TYPE",  
    barmode="group",  
    title="Revenue Breakdown by State"  
)
```

Revenue Breakdown by State



ASSIGNMENT: BAR CHARTS



1 NEW MESSAGE
March 9, 2023

From: Leonard Lift (Ski Trip Concierge)
Subject: National Lift Characteristics

Hey there,

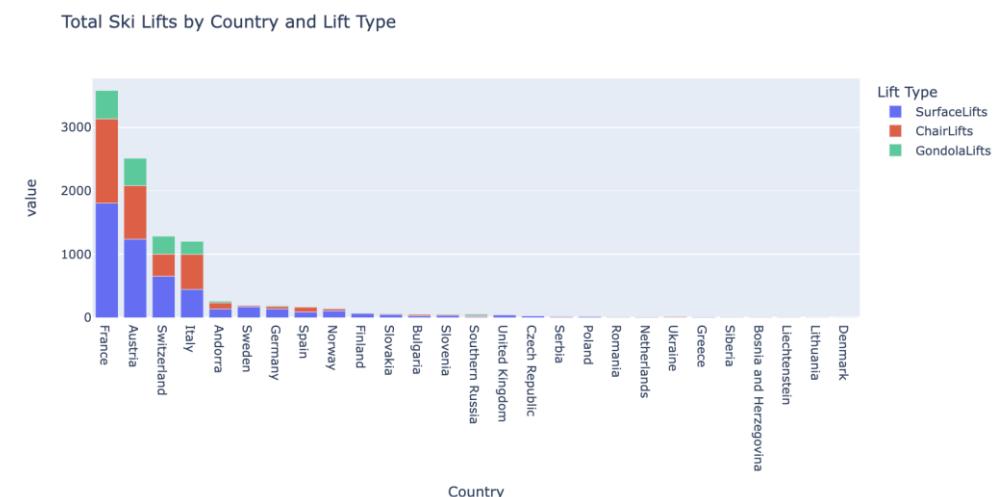
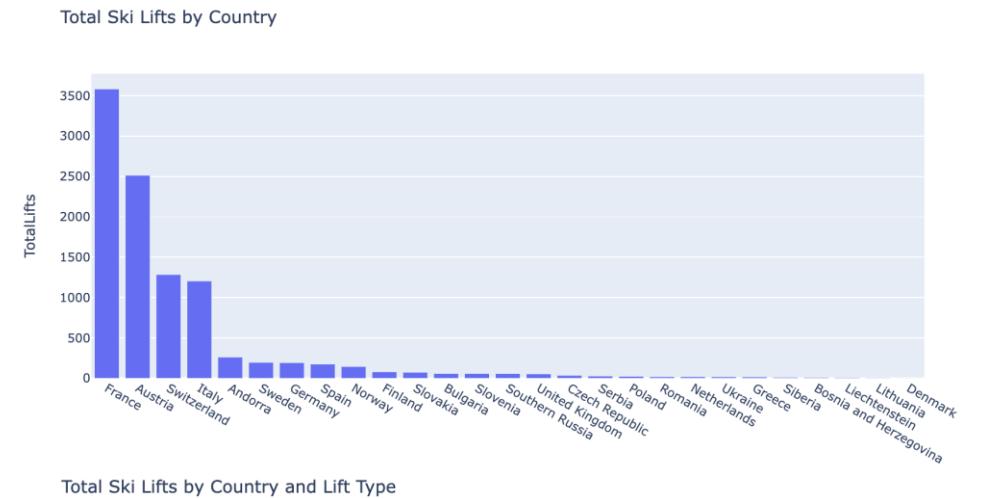
We get questions from customers about which countries not only have the most ski lifts (some like to do multi-country tours) but also what types of lifts are available. Some customers really like gondola lifts for whatever reason.

Could you produce a bar chart of lift count by country, and a second one that has these lifts broken out by lift category?

Thanks!

Results Preview



SOLUTION: BAR CHARTS

 NEW MESSAGE
March 9, 2023

From: Leonard Lift (Ski Trip Concierge)
Subject: National Lift Characteristics

Hey there,

We get questions from customers about which countries not only have the most ski lifts (some like to do multi-country tours) but also what types of lifts are available. Some customers really like gondola lifts for whatever reason.

Could you produce a bar chart of lift count by country, and a second one that has these lifts broken out by lift category?

Thanks!

Solution Code

Standard Bar Chart:

```
px.bar(  
    lift_type_by_country,  
    x="Country",  
    y="TotalLifts",  
    title="Total Ski Lifts by Country"  
)
```

Stacked Bar Chart:

```
px.bar(  
    lift_type_by_country,  
    x="Country",  
    y=[ "SurfaceLifts", "ChairLifts", "GondolaLifts"],  
    title="Total Ski Lifts by Country and Lift Type"  
.update_layout(legend_title_text="Lift Type")
```



PRO TIP: BUBBLE CHARTS

Plotly Figures

Basic Charts

Chart Formatting

Map Visuals

You can turn a scatterplot into a **bubble chart** by using the “size” argument

expenditure.head()

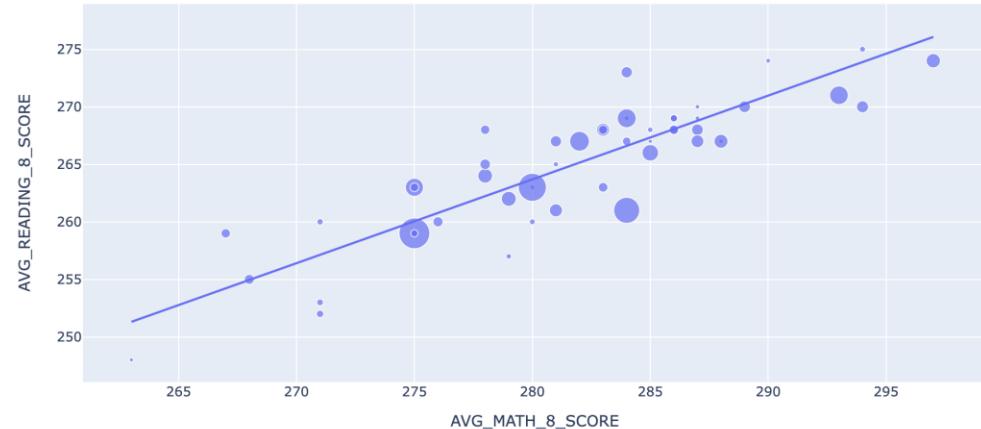
	STATE	TOTAL_EXPENDITURE	AVG_MATH_8_SCORE	AVG_READING_8_SCORE
1173	ALABAMA	7501799.0	267.0	259.0
1174	ALASKA	2968341.0	280.0	260.0
1175	ARIZONA	7902600.0	283.0	263.0
1176	ARKANSAS	5350543.0	275.0	259.0
1177	CALIFORNIA	78365958.0	275.0	259.0

```
px.scatter(  
    expenditure,  
    x="AVG_MATH_8_SCORE",  
    y="AVG_READING_8_SCORE",  
    size="TOTAL_EXPENDITURE",  
    trendline="ols",  
    title = "Math & Reading Scores by Spend"  
)
```

Math & Reading Scores by Spend



PRO TIP: Use `trendline="ols"`
to add the regression line





PRO TIP: DONUT CHARTS

Plotly Figures

Basic Charts

Chart Formatting

Map Visuals

You can turn a pie into a **donut chart** by using the “hole” argument

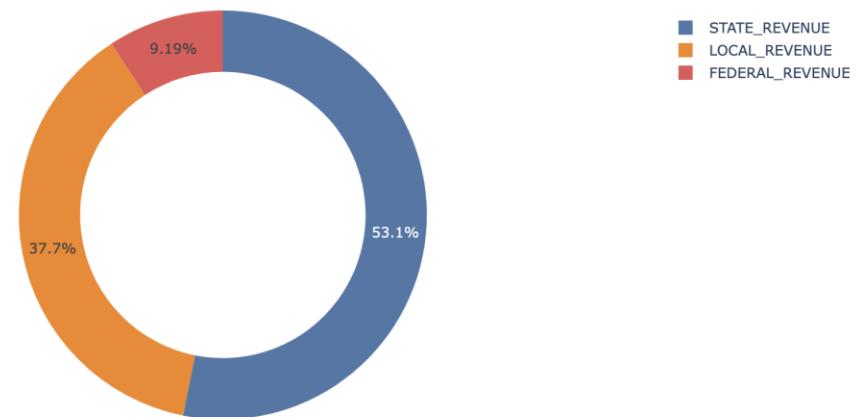
- Other options include changing the sort order, and modifying the color sequence

revenue			
	STATE	TYPE	REVENUE
4	CALIFORNIA	FEDERAL_REVENUE	7556365.0
12	IDAHO	FEDERAL_REVENUE	232449.0
21	MASSACHUSETTS	FEDERAL_REVENUE	778939.0
33	NORTH_CAROLINA	FEDERAL_REVENUE	1589570.0
57	CALIFORNIA	STATE_REVENUE	42360470.0
65	IDAHO	STATE_REVENUE	1381205.0
74	MASSACHUSETTS	STATE_REVENUE	6808436.0
86	NORTH_CAROLINA	STATE_REVENUE	8172685.0
110	CALIFORNIA	LOCAL_REVENUE	28331207.0
118	IDAHO	LOCAL_REVENUE	554313.0
127	MASSACHUSETTS	LOCAL_REVENUE	9397810.0
139	NORTH_CAROLINA	LOCAL_REVENUE	3384679.0

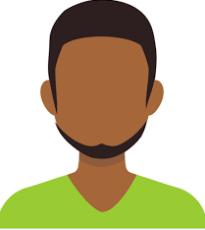


```
px.pie(  
    revenue,  
    values="REVENUE",  
    names="TYPE",  
    hole=0.7,  
    category_orders={"TYPE": ["STATE_REVENUE", "LOCAL_REVENUE", "FEDERAL_REVENUE"]},  
    color_discrete_sequence=px.colors.qualitative.T10,  
    title="Revenue Breakdown"  
)
```

Revenue Breakdown



ASSIGNMENT: BUBBLE & DONUT CHARTS

 **1 NEW MESSAGE**
March 9, 2023

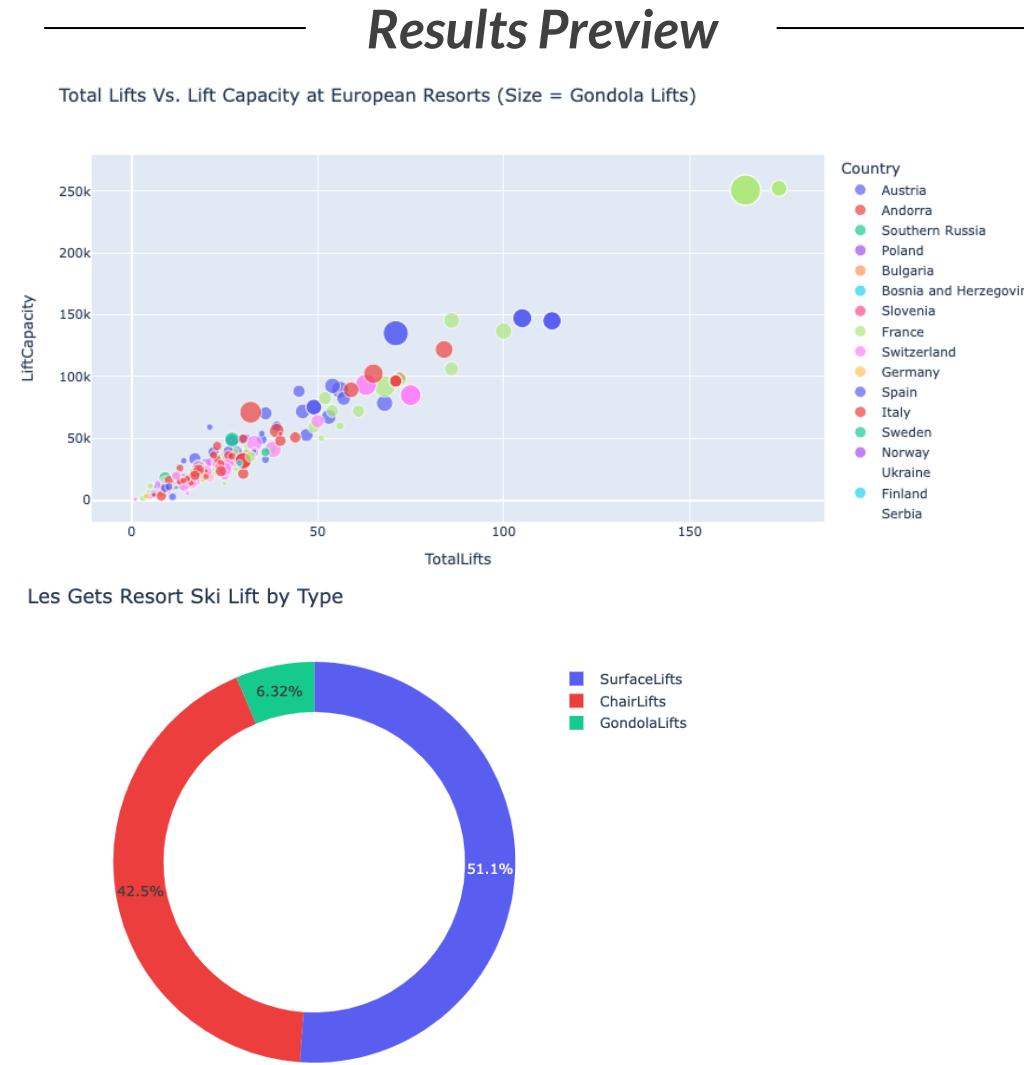
From: Leonard Lift (Ski Trip Concierge)
Subject: RE: Info for Client

Hi again,

Thanks for getting me those charts, the client was really pleased! Somewhat related, this client hates waiting in line at lifts, and believes resorts with high lift capacity and lift numbers will have shorter waits. They also prefer Gondola lifts. Can you build a bubble chart that compares TotalLifts to LiftCapacity with the size of each marker as the number of Gondola Lifts?

Then build a donut chart breaking down lift types for the resort with the highest lift capacity.



SOLUTION: BUBBLE & DONUT CHARTS



NEW MESSAGE

March 9, 2023

From: **Leonard Lift** (Ski Trip Concierge)
Subject: RE: Info for Client

Hi again,

Thanks for getting me those charts, the client was really pleased! Somewhat related, this client hates waiting in line at lifts, and believes resorts with high lift capacity and lift numbers will have shorter waits. They also prefer Gondola lifts. Can you build a bubble chart that compares TotalLifts to LiftCapacity with the size of each marker as the number of Gondola Lifts?

Then build a donut chart breaking down lift types for the resort with the highest lift capacity.



section02_solutions.ipynb

Reply

Forward

Solution Code

Bubble Chart:

```
px.scatter(  
    ski_resorts,  
    "TotalLifts",  
    "LiftCapacity",  
    color="Country",  
    size="GondolaLifts",  
    title="Total Lifts Vs. Lift Capacity at European Resorts (Size = Gondola Lifts)"  
)
```

Donut Chart:

```
les_gets = (  
    ski_resorts  
    .loc[ski_resorts["LiftCapacity"].argmax()].iloc[[-6, -5, -4]]  
    .reset_index()  
    .rename({"index": "lift_type", 265: "count"}, axis=1)  
)  
  
les_gets
```

lift_type	count
SurfaceLifts	89
ChairLifts	74
GondolaLifts	11

```
px.pie(  
    les_gets,  
    values="count",  
    names="lift_type",  
    hole=.75,  
    category_orders = {"lift_type": ["SurfaceLifts", "ChairLifts", "GondolaLifts"]},  
    title="Les Gets Resort Ski Lift by Type"  
)
```



HISTOGRAM OPTIONS

Plotly Figures

Basic Charts

Chart Formatting

Map Visuals

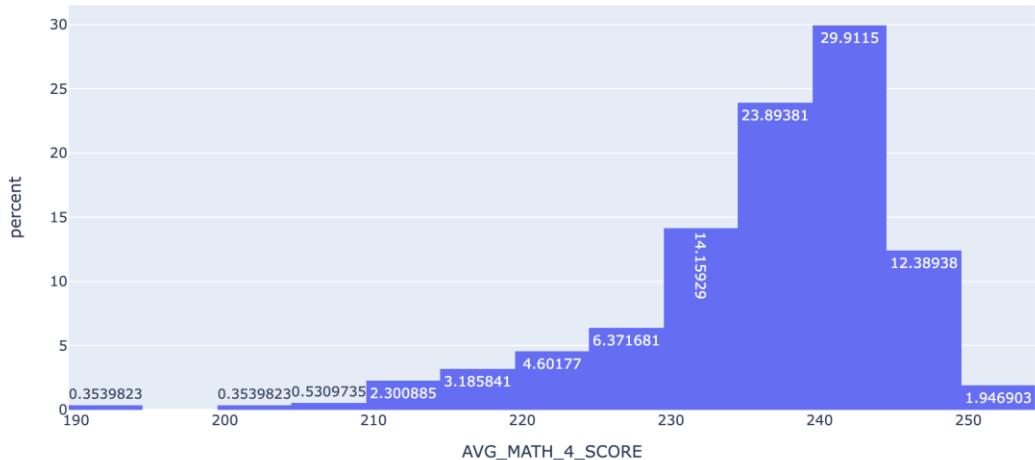
```
grades.head()
```

	STATE	YEAR	AVG_MATH_4_SCORE
0	ALABAMA	1992	208.0
1	ALASKA	1992	NaN
2	ARIZONA	1992	215.0
3	ARKANSAS	1992	210.0
4	CALIFORNIA	1992	208.0



```
px.histogram(  
    grades,  
    x="AVG_MATH_4_SCORE",  
    nbins=20,  
    histnorm="percent",  
    text_auto=True,  
    title="4th Grade Math Scores"  
)
```

4th Grade Math Scores





UPDATE METHODS

Plotly Figures

Basic Charts

Chart Formatting

Map Visuals

Update methods let you format Plotly Express charts using object-oriented commands, combining the best of both worlds!

- While Plotly Express does have formatting options, update methods are occasionally useful

update_layout

Modifies chart elements like the title, legend, fonts, figure size, and more

`px.line(...).update_layout(legend_title, ...)`

update_traces

Modifies plotted data like the line styles, colors, markers, and more

`px.line(...).update_traces(opacity, ...)`

update_xaxes

Modifies the x-axis formatting, including the ticks, units, and text

`px.line(...).update_xaxes(nticks, ...)`

update_yaxes

Modifies the y-axis formatting, including the ticks, units, and text

`px.line(...).update_yaxes(showgrid, ...)`

This can be any chart type





UPDATE LAYOUT

Plotly Figures

Basic Charts

Chart Formatting

Map Visuals

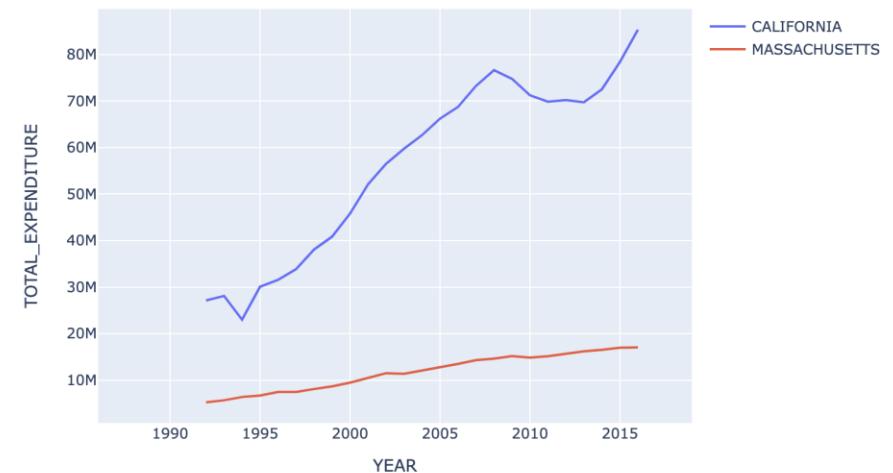
The **.update_layout()** method lets you customize figure and plot elements

- This is commonly used to modify the title and legend formatting, as well as fonts and colors

```
px.line(  
    education.query("STATE in ['CALIFORNIA', 'MASSACHUSETTS']"),  
    x="YEAR",  
    y="TOTAL_EXPENDITURE",  
    color="STATE",  
    title="Education Spend by State"  
).update_layout(  
    title_font = dict(  
        color="grey",  
        size=24  
    ),  
    title = {  
        "x": .43,  
        "y": .9,  
        "xanchor": "center"  
    },  
    legend_title="",  
    width=750  
)
```



Education Spend by State



This modifies the title's color, size, and position, removes the legend title, and changes the figure's width



UPDATE LAYOUT

Plotly Figures

Basic Charts

Chart Formatting

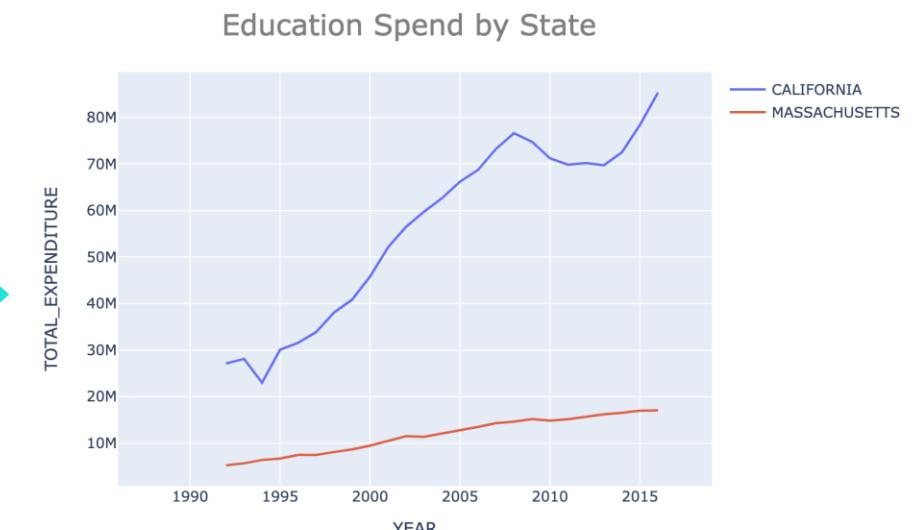
Map Visuals

The **.update_layout()** method lets you customize figure and plot elements

- This is commonly used to modify the title and legend formatting, as well as fonts and colors

```
fig = px.line(  
    education.query("STATE in ['CALIFORNIA', 'MASSACHUSETTS']"),  
    x="YEAR",  
    y="TOTAL_EXPENDITURE",  
    color="STATE",  
    title="Education Spend by State"  
)
```

```
fig.update_layout(  
    title_font = dict(  
        color="grey",  
        size=24  
    ),  
    title = {  
        "x": .43,  
        "y": .9,  
        "xanchor": "center",  
    },  
    legend_title="",  
    width=750  
)
```



By assigning the Plotly Express chart to a variable “fig”, you can gradually apply chart formatting using update methods



UPDATE TRACES

Plotly Figures

Basic Charts

Chart Formatting

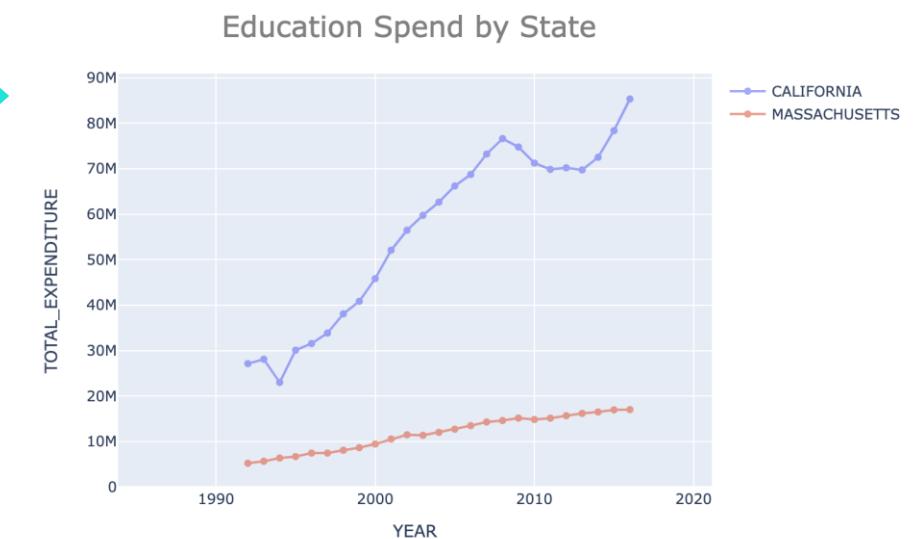
Map Visuals

The **.update_traces()** method lets you modify the formatting of the plotted data

- This is commonly used to change the styling, colors, and opacity

```
fig.update_traces(  
    mode="lines+markers",  
    opacity=.6  
)
```

This adds markers to the line charts and changes their opacity





UPDATE AXES

Plotly Figures

Basic Charts

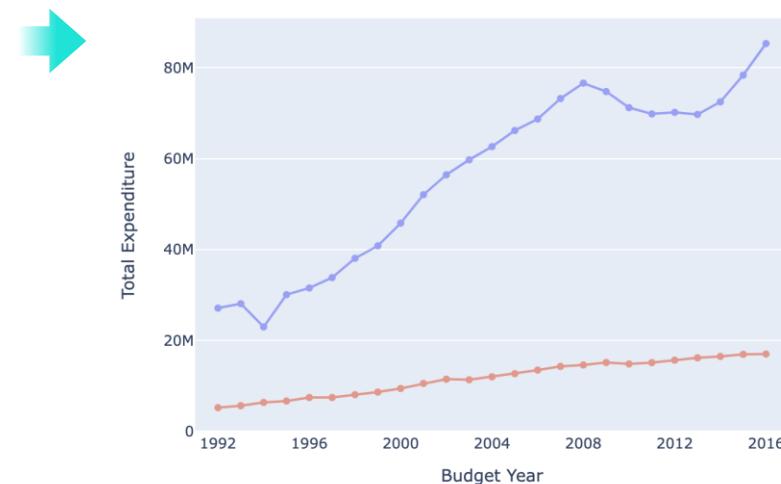
Chart Formatting

Map Visuals

The `.update_xaxes()` & `.update_yaxes()` methods let you format each axis

- This is commonly used to customize the gridlines, ranges, and tick marks

```
fig.update_xaxes(  
    title="Budget Year",  
    showgrid=False,  
    range=[1991,2017],  
    dtick=4  
)  
  
fig.update_yaxes(  
    title="Total Expenditure",  
    nticks=5  
)
```



For the x-axis, this changes the title, removes the gridlines, modifies the range of years, and sets the ticks every 4 years

For the y-axis, this changes the title, and sets 5 ticks in total



PRO TIP: TREATING DATES AS TEXT

Plotly Figures

Basic Charts

Chart Formatting

Map Visuals

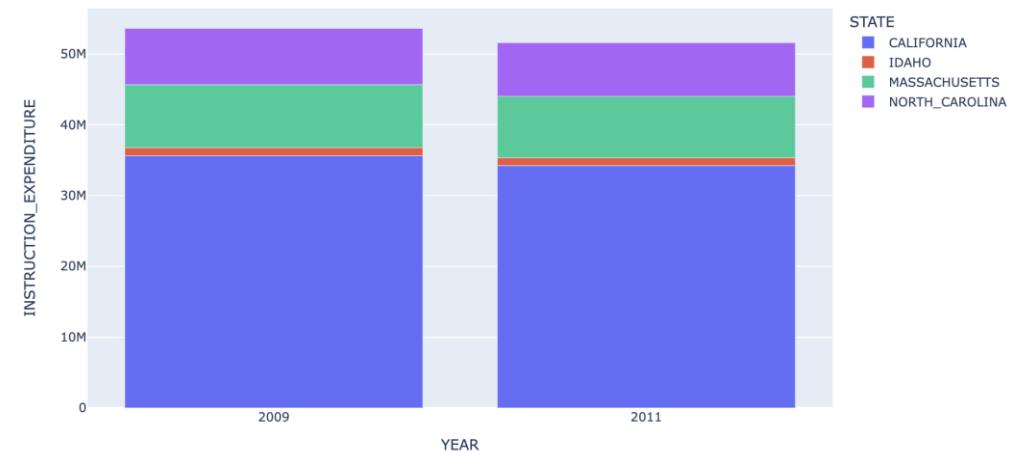
You can use `.update_xaxes(type="category")` to avoid gaps when using dates

education2years

	YEAR	STATE	INSTRUCTION_EXPENDITURE
871	2009	CALIFORNIA	35617964.0
879	2009	IDAHO	1157633.0
888	2009	MASSACHUSETTS	8885949.0
900	2009	NORTH_CAROLINA	7943541.0
973	2011	CALIFORNIA	34225248.0
981	2011	IDAHO	1104553.0
990	2011	MASSACHUSETTS	8685894.0
1002	2011	NORTH_CAROLINA	7566249.0

Note that 2010 is missing!

```
px.bar(  
    education2years,  
    x="YEAR",  
    y="INSTRUCTION_EXPENDITURE",  
    color="STATE"  
).update_xaxes(type="category")
```





ADDING ANNOTATIONS

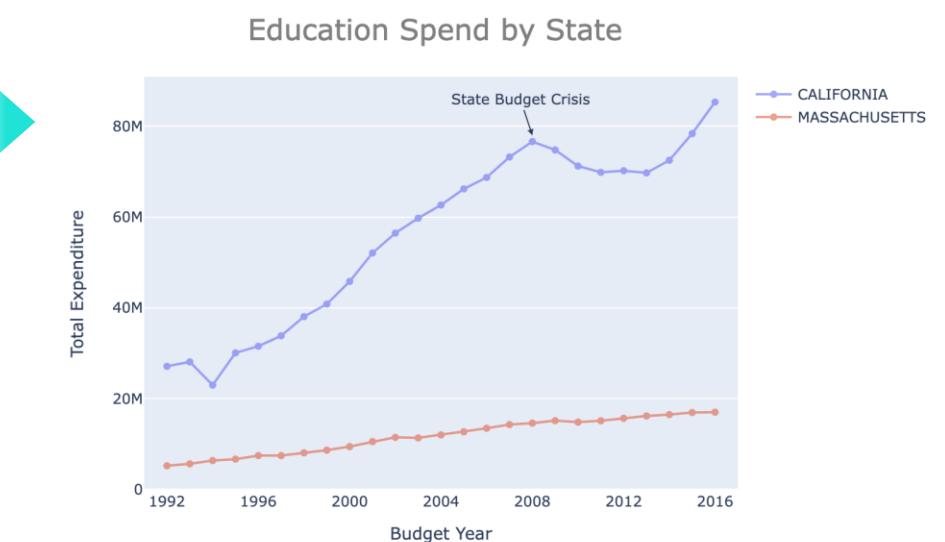
Plotly Figures

Basic Charts

Chart Formatting

Map Visuals

```
fig.add_annotation(  
    text="State Budget Crisis",  
    x=2008,  
    y=78000000,  
    arrowhead=2  
)
```





ADDING TRACES

Plotly Figures

Basic Charts

Chart Formatting

Map Visuals

```
import plotly.graph_objects as go

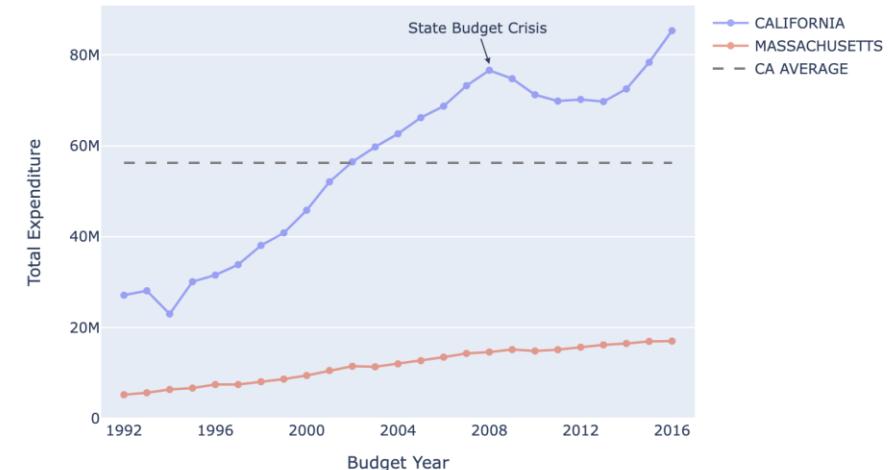
ca_mean = education.loc[
    education["STATE"]=="CALIFORNIA",
    "TOTAL_EXPENDITURE"
].mean()

reference_line = go.Scatter(
    x=(1992,2016),
    y=(ca_mean, ca_mean),
    mode="lines",
    line={"color":"gray", "dash":"dash"}, 
    name="CA AVERAGE"
)

fig.add_trace(
    reference_line
)
```



Education Spend by State



ASSIGNMENT: CHART FORMATTING

 **NEW MESSAGE**
March 12, 2023

From: Leonard Lift (Ski Trip Concierge)
Subject: Aesthetics

Hi,

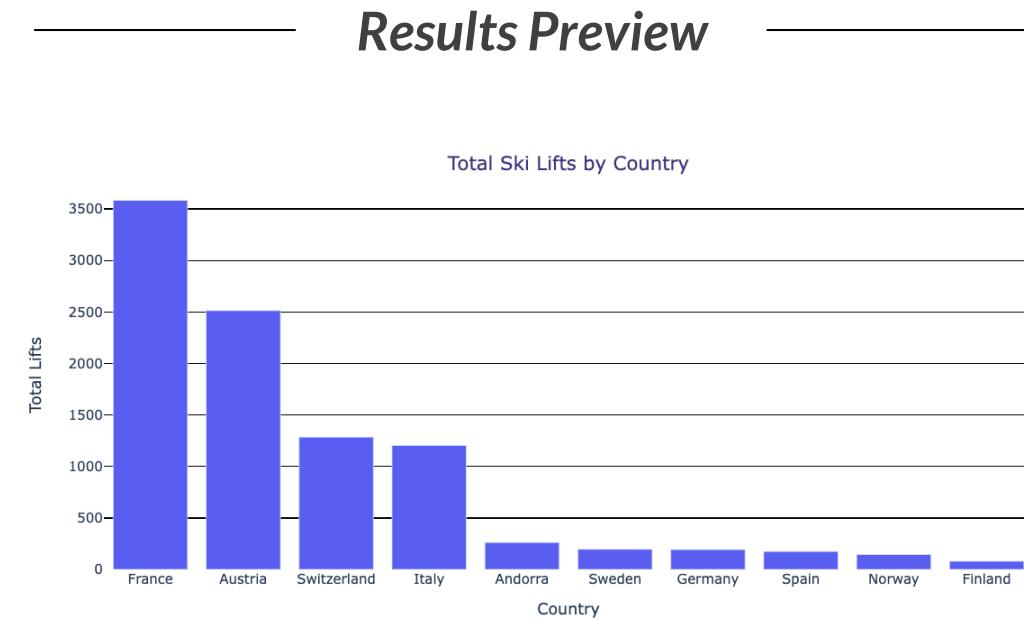
One of our clients has asked for some changes to the aesthetics of the bar chart we made earlier.

Additionally, they want to limit the view to the top 10 countries.

I've added details in the notebook.

Thanks!



SOLUTION: CHART FORMATTING

 NEW MESSAGE
March 12, 2023

From: Leonard Lift (Ski Trip Concierge)
Subject: Aesthetics

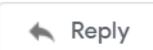
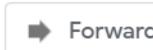
Hi,

One of our clients has asked for some changes to the aesthetics of the bar chart we made earlier.

Additionally, they want to limit the view to the top 10 countries.

I've added details in the notebook.

Thanks!

 section02_solutions.ipynb  Reply  Forward

Solution Code

```
lift_type_by_country = (
    ski_resorts
    .groupby("Country", as_index=False)
    .agg({"SurfaceLifts": "sum", "ChairLifts": "sum", "GondolaLifts": "sum", "TotalLifts": "sum"})
    .sort_values("TotalLifts", ascending=False)
    .iloc[:10]
)

px.bar(
    lift_type_by_country,
    x="Country",
    y="TotalLifts",
    title="Total Ski Lifts by Country"
).update_layout(
    title = {"x": .5, "y": .85, "font": {"color": "darkslateblue"}},
    plot_bgcolor="#FFFFFF",
    paper_bgcolor="#FFFFFF"
).update_yaxes(
    {"title": "Total Lifts"},
    gridcolor="black"
)
```



MAP-BASED VISUALS

Plotly Figures

Basic Charts

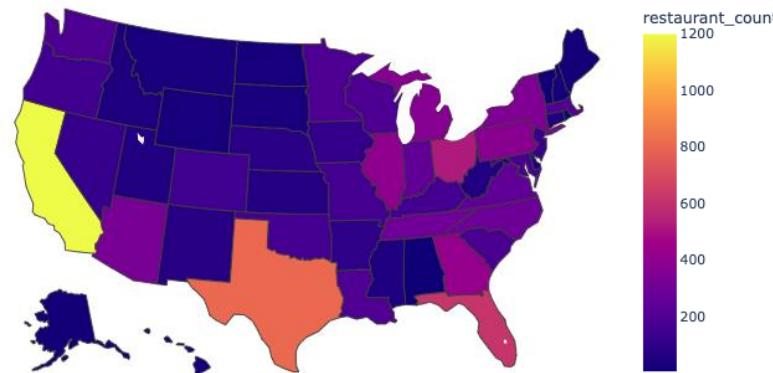
Chart Formatting

Map Visuals

Plotly Express also has functions for **map-based visuals** using geographical data:

- `px.choropleth` uses geographic regions (countries, states, etc.)
- `px.scatter_mapbox` and `px.density_mapbox` use latitude & longitude pairs

Fast Food Restaurants by State



Fast Food Revenue Distribution



PRO TIP: Plotly has built-in options for plotting countries and US states, but Googling examples for other regions is a great way to avoid creating a custom solution from scratch



CHOROPLETH MAPS

Plotly Figures

Basic Charts

Chart Formatting

Map Visuals

Choropleth maps are created with the px.choropleth() function

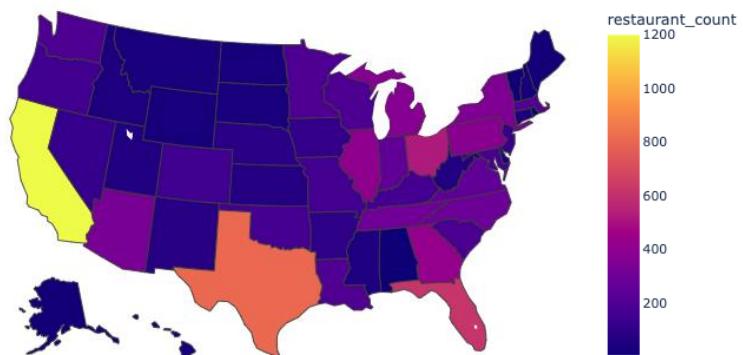
Like all Plotly Express charts, the first argument is the DataFrame, followed by:

- **locations**: the DataFrame column that contains the geographical data (state, country, etc.)
- **locationmode**: the type of geographical data used ("ISO-3", "USA-states", or "country names")
- **color**: the numerical DataFrame column that will determine the shade of each region
- **scope**: the range of the map shown (*default is "world", others include "usa", "europe", "asia", etc.*)

fast_food_by_state.head()		
province	restaurant_count	
0 AK	16	
1 AL	6	
2 AR	102	
3 AZ	330	
4 CA	1201	

```
px.choropleth(  
    fast_food_by_state,  
    locations="province",  
    color="restaurant_count",  
    locationmode="USA-states",  
    scope="usa",  
    title="Fast Food Restaurants by State"  
)
```

Fast Food Restaurants by State



The **locations & location_mode** must match for the map to be created properly



PRO TIP: MAPBOX MAPS

Plotly Figures

Basic Charts

Chart Formatting

Map Visuals

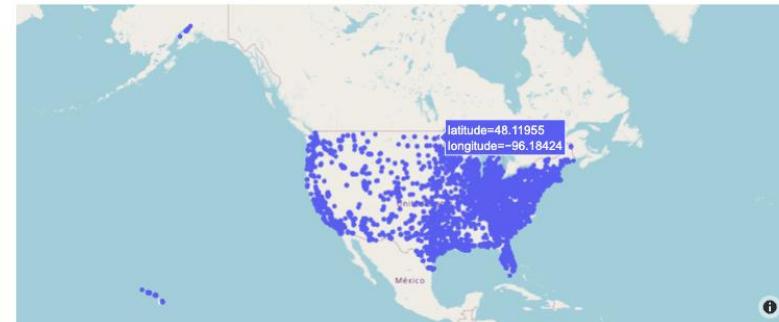
```
fast_food.head()
```

	city	country	latitude	longitude	revenue
0	Thibodaux	US	29.814697	-90.814742	10974.865182
1	Thibodaux	US	29.814697	-90.814742	82284.225538
2	Pigeon Forge	US	35.803788	-83.580553	52336.439630
3	Pigeon Forge	US	35.782339	-83.551408	20083.872548
4	Morrow	US	33.562738	-84.321143	73965.018760



```
px.scatter_mapbox(  
    fast_food,  
    lat="latitude",  
    lon="longitude",  
    center={"lat": 44.5, "lon": -103.5},  
    zoom=2,  
    mapbox_style="open-street-map",  
    title="US Fast Food Restaurant Locations"  
)
```

US Fast Food Restaurant Locations



The “center” & “zoom” arguments let you set a default view for the map



PRO TIP: MAPBOX MAPS

Plotly Figures

Basic Charts

Chart Formatting

Map Visuals

Mapbox maps use an open-source mapping API integrated into Plotly to create map-based visuals using latitude & longitude pairs

```
fast_food.head()
```

	city	country	latitude	longitude	revenue
0	Thibodaux	US	29.814697	-90.814742	10974.865182
1	Thibodaux	US	29.814697	-90.814742	82284.225538
2	Pigeon Forge	US	35.803788	-83.580553	52336.439630
3	Pigeon Forge	US	35.782339	-83.551408	20083.872548
4	Morrow	US	33.562738	-84.321143	73965.018760



```
px.density_mapbox(  
    fast_food,  
    lat="latitude",  
    lon="longitude",  
    z="revenue",  
    radius=fast_food["revenue"]/10000,  
    center={"lat": 44.5, "lon": -103.5},  
    zoom=2,  
    mapbox_style="stamen-terrain",  
    title="Fast Food Revenue Distribution"  
)
```

The “z” & “radius” arguments let you specify a numerical field for the heatmap

Fast Food Revenue Distribution



PRO TIP: You can use the px.density_mapbox() function to create a heatmap style map



ASSIGNMENT: MAPS

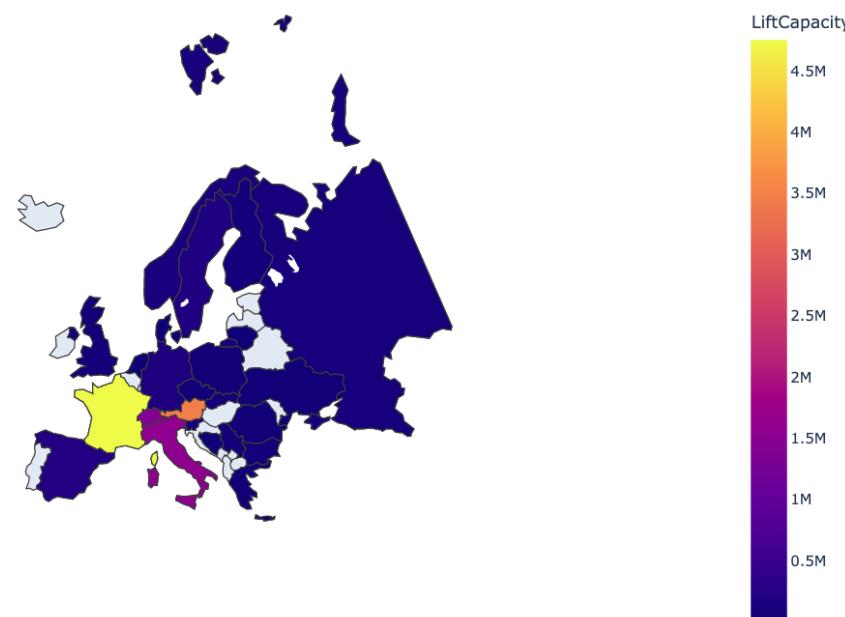
 NEW MESSAGE
March 11, 2023

From: **Leonard Lift** (Ski Trip Concierge)
Subject: Lift Capacity

Ok,
This is hopefully the last need for our client (and me, the lowly concierge).
Can we get a map-based view of lift capacity in each country?
Should be easier to digest than a bar chart for this purpose.
Thanks!

Results Preview



SOLUTION: MAPS

 NEW MESSAGE
March 11, 2023

From: Leonard Lift (Ski Trip Concierge)
Subject: Lift Capacity

Ok,

This is hopefully the last need for our client (and me, the lowly concierge).

Can we get a map-based view of lift capacity in each country?

Should be easier to digest than a bar chart for this purpose.

Thanks!

 section02_solutions.ipynb  Reply  Forward

Solution Code

```
px.choropleth(  
    (ski_resorts  
     .groupby("Country", as_index=False)  
     .agg({"LiftCapacity": "sum"}))  
,  
    locations="Country",  
    color="LiftCapacity",  
    locationmode="country names",  
    scope="europe",  
    # may need to play with height/width/margins for ideal view  
    height=800,  
    width=1000  
).update_layout(coloraxis_showscale=False) # may want to remove scale
```

KEY TAKEAWAYS



Plotly has **two methods** for creating charts

- *Plotly Graph Objects is an object-oriented approach that offers extreme customization*
- *Plotly Express is an intuitive functional framework that lets you easily create & customize charts*



Plotly Express has functions for most basic chart types

- *By reading in a DataFrame you can create line charts, bar charts, pie charts, scatterplots, and histograms*



Use **update methods** to customize the layout, plot, and axes of your charts

- *These leverage the object-oriented approach to creating charts for combining the best of both worlds*



Geographical data can be plotted with **choropleth maps**

- *Plotly Express has built-in options for countries and US states, but solutions for other regions can be found online*

INTERACTIVE ELEMENTS



INTERACTIVE ELEMENTS



In this section we'll cover **interactive elements** from the Dash Core Components module, and use them to provide different data inputs for manipulating Plotly visuals in Dash apps

TOPICS WE'LL COVER:

Basic Interactivity

Interactive Elements

Multiple Input Callbacks

Multiple Output Callbacks

GOALS FOR THIS SECTION:

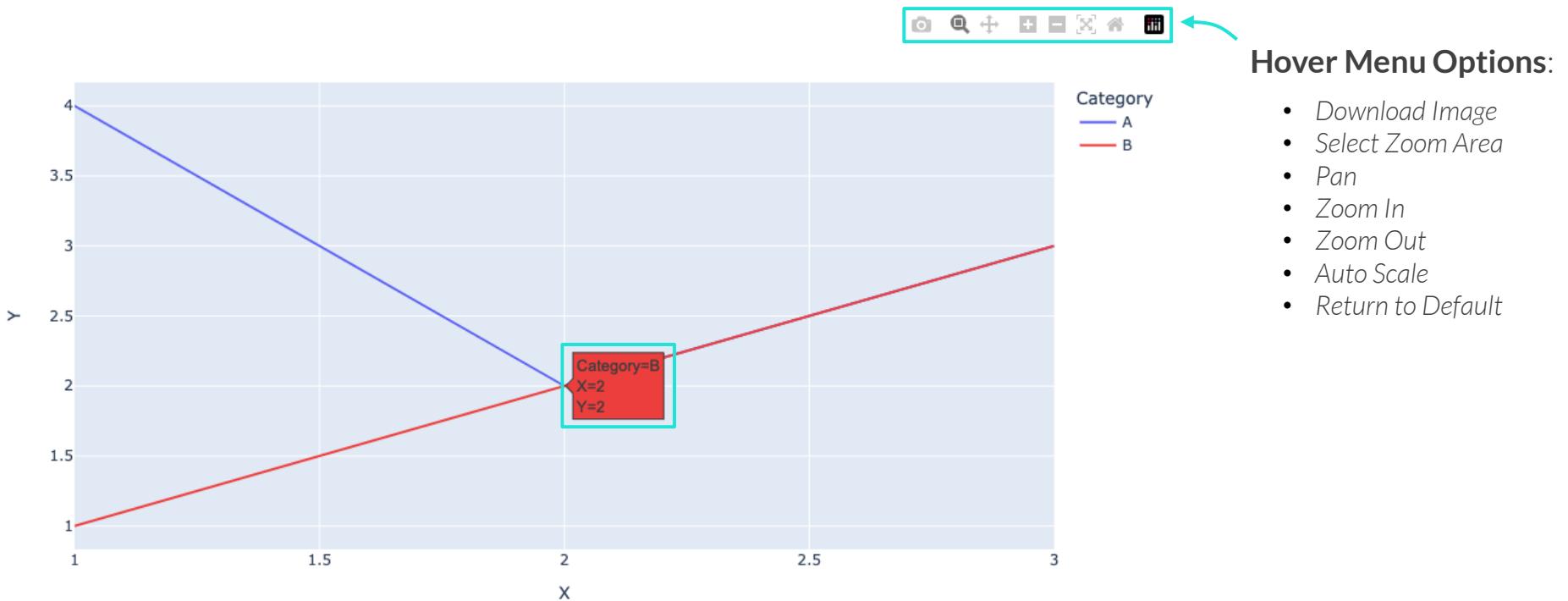
- Identify the various types of components used to interact with Plotly visuals in Dash and their use cases
- Learn to create & format interactive elements and process their inputs through callback functions
- Add multiple interactive elements to your Dash apps and write callback functions to handle multiple inputs



BASIC INTERACTIVITY

Plotly figures have some **basic interactivity** by default

- This includes tool tips with data labels, the ability to zoom in & out, and more!



Basic
Interactivity

Interactive
Elements

Multiple Input
Callbacks

Multiple Output
Callbacks



INTERACTIVE ELEMENTS

Basic
Interactivity

Interactive
Elements

Multiple Input
Callbacks

Multiple Output
Callbacks

The Dash Core Components (dcc) module has several **interactive elements** that can be used in Dash apps to create dynamic dashboards with Plotly figures

Component	Description	Logical Operators
dcc.Dropdown()	Dropdown list of options for the user to select (or multi-select)	<code>==, !=, in, not in</code>
dcc.Checklist()	Checkboxes with options for the user to select or deselect	<code>==, !=, in, not in</code>
dcc.RadioItems()	Radio buttons with options for the user to toggle between	<code>==, !=, in, not in</code>
dcc.Slider()	Slider with a handle for the user to drag and select values with	<code>==, <, <=, >, >=</code>
dcc.RangeSlider()	Slider with two handles for the user to drag and select ranges with	<code>.between(value[0], value[1])</code>
dcc.DatePickerSingle()	Dropdown calendar for the user to select a date with	<code>==, <, <=, >, >=</code>
dcc.DatePickerRange()	Dropdown calendar for the user to select a date range with	<code>.between(start, end)</code>



Other key considerations to discuss are **data types** and the **number of options available** to users

These are used in the callback functions to filter the visuals based on the user selections



DROPDOWN MENUS

Basic
Interactivity

Interactive
Elements

Multiple Input
Callbacks

Multiple Output
Callbacks

Dropdown menus provide a list of options for the user to select (or multi-select)

- `dcc Dropdown(id, options, value, multi)`

```
dcc.Dropdown(  
    id="X Column Picker",  
    options=list(education.select_dtypes(include='number').columns),  
    value="expenditure_per_student",  
)
```

This sets the names for the columns with numerical data types as the options

expenditure_per_student
SUPPORT_SERVICES_EXPENDITURE
OTHER_EXPENDITURE
CAPITAL_OUTLAY_EXPENDITURE
GRADES_ALL_G
AVG_MATH_8_SCORE
expenditure_per_student

```
dcc.Dropdown(  
    id="X Column Picker",  
    options=[  
        {"value": "AVG_MATH_8_SCORE", "label": "Avg Math 8 Score"},  
        {"value": "expenditure_per_student", "label": "Expenditure Per Student"}  
    value="expenditure_per_student",  
)
```

You can use **dictionaries** to show users labels in the dropdown that are different from the values passed through

Expenditure Per Student
Avg Math 8 Score
Expenditure Per Student



DROPDOWN MENUS

Basic
Interactivity

Interactive
Elements

Multiple Input
Callbacks

Multiple Output
Callbacks

EXAMPLE

Changing the dependent “x” variable in a scatterplot with a regression line

```
app = JupyterDash(__name__)

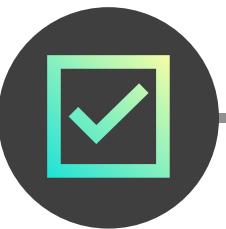
app.layout = html.Div([
    dcc.Dropdown(
        id="X Column Picker",
        options=list(
            education.select_dtypes(include="number").columns
        ),
        value="expenditure_per_student"
    ),
    dcc.Graph(id="Graph")
])

@app.callback(
    Output("Graph", "figure"),
    Input("X Column Picker", "value")
)
def plot_rev_scatter(x):
    if not x:
        raise PreventUpdate
    fig = px.scatter(
        education,
        x=x,
        y="AVG_MATH_8_SCORE",
        trendline="ols",
        title=f"Relationship between {x} & AVG_MATH_8_SCORE"
    )
    return fig

if __name__ == "__main__":
    app.run_server(mode="inline")
```

This lets the user select a numerical column in the dropdown, and sets “expenditure_per_student” as the default

The selection gets passed into the callback function and used as the “x” variable in the scatterplot, returning the updated chart



DROPDOWN MENUS

Basic
Interactivity

Interactive
Elements

Multiple Input
Callbacks

Multiple Output
Callbacks

EXAMPLE

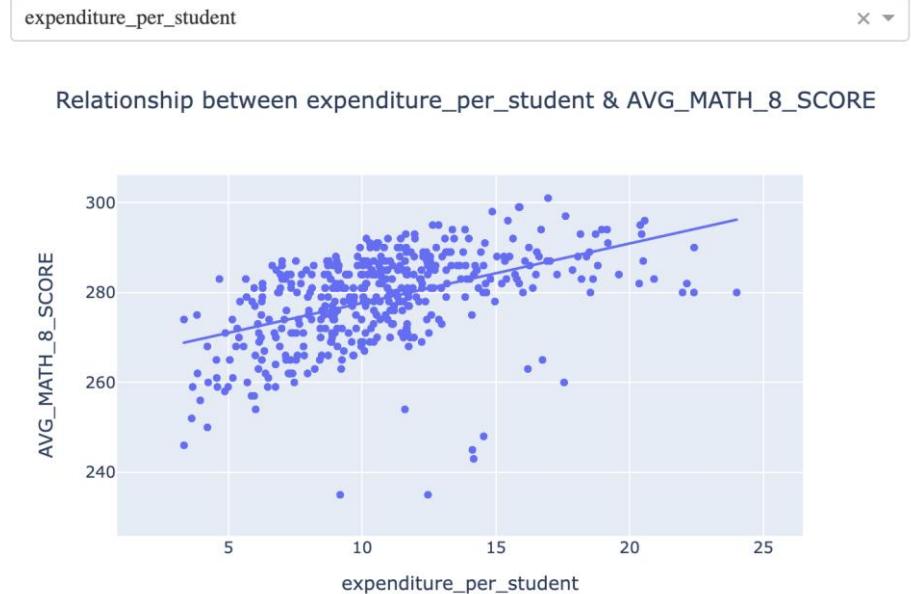
Changing the dependent “x” variable in a scatterplot with a regression line

```
app = JupyterDash(__name__)

app.layout = html.Div([
    dcc.Dropdown(
        id="X Column Picker",
        options=list(
            education.select_dtypes(include="number").columns
        ),
        value="expenditure_per_student"
    ),
    dcc.Graph(id="Graph")
])

@app.callback(
    Output("Graph", "figure"),
    Input("X Column Picker", "value")
)
def plot_rev_scatter(x):
    if not x:
        raise PreventUpdate
    fig = px.scatter(
        education,
        x=x,
        y="AVG_MATH_8_SCORE",
        trendline="ols",
        title=f"Relationship between {x} & AVG_MATH_8_SCORE"
    )
    return fig

if __name__ == "__main__":
    app.run_server(mode="inline")
```





MULTI-SELECT DROPDOWN MENUS

Basic
Interactivity

Interactive
Elements

Multiple Input
Callbacks

Multiple Output
Callbacks

You can create **multi-select dropdown menus** with the “multi” argument

- This passes a list to the callback function instead of a string

```
app = JupyterDash(__name__)

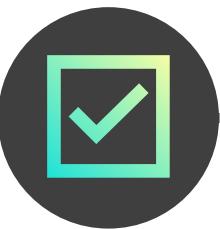
app.layout = html.Div([
    dcc.Dropdown(
        id="filter",
        options=education["STATE"].unique(),
        value=["CALIFORNIA", "OREGON"],
        multi=True
    ),
    dcc.Graph(id="graph")
])

@app.callback(
    Output("graph", "figure"),
    Input("filter", "value")
)
def plot_rev_scatter(state):
    fig = px.line(
        education.query("STATE in @state"),
        x="YEAR",
        y="TOTAL_EXPENDITURE",
        color="STATE",
        title="Expenditure Over Time"
    )
    return fig

if __name__ == "__main__":
    app.run_server(mode="inline")
```

This sets the unique “STATE” values as the options, with “CALIFORNIA” and “OREGON” as the default, and enables multi-select

The “in” logical operator lets you process the list, and the “color” argument plots a series for each state



MULTI-SELECT DROPDOWN MENUS

Basic
Interactivity

Interactive
Elements

Multiple Input
Callbacks

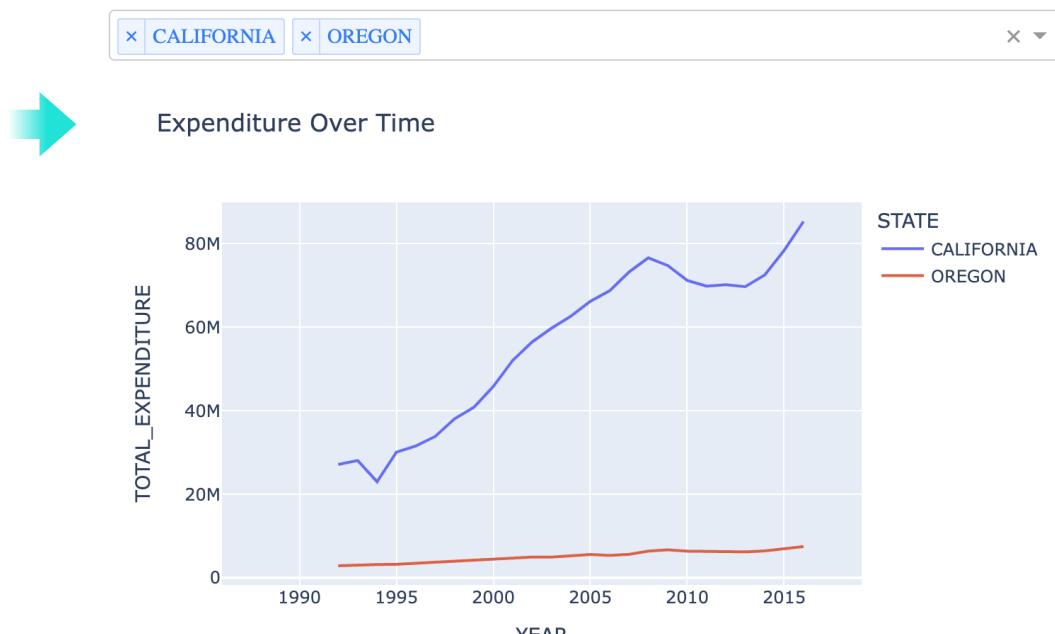
Multiple Output
Callbacks

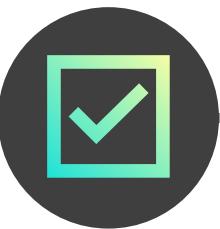
```
app = JupyterDash(__name__)

app.layout = html.Div([
    dcc.Dropdown(
        id="filter",
        options=education["STATE"].unique(),
        value=["CALIFORNIA", "OREGON"],
        multi=True
    ),
    dcc.Graph(id="graph")
])

@app.callback(
    Output("graph", "figure"),
    Input("filter", "value")
)
def plot_rev_scatter(state):
    fig = px.line(
        education.query("STATE in @state"),
        x="YEAR",
        y="TOTAL_EXPENDITURE",
        color="STATE",
        title="Expenditure Over Time"
    )
    return fig

if __name__ == "__main__":
    app.run_server(mode="inline")
```





CHECKLISTS

Basic
Interactivity

Interactive
Elements

Multiple Input
Callbacks

Multiple Output
Callbacks

Checklists provide a list of options for the user to select (or multi-select)

- `dcc.Checklist(id, options, value)`

```
app = JupyterDash(__name__)

app.layout = html.Div([
    dcc.Checklist(
        id="scores",
        options=[
            "AVG_MATH_4_SCORE",
            "AVG_MATH_8_SCORE",
            "AVG_READING_4_SCORE",
            "AVG_READING_8_SCORE"
        ],
        value=["AVG_MATH_4_SCORE"]
    ),
    dcc.Graph(id="graph")
])

@app.callback(
    Output("graph", "figure"),
    Input("scores", "value")
)
def plot_rev_hist(scores):
    fig = px.histogram(
        education,
        x=scores,
        barmode="overlay",
        title="Score Distribution"
    ).update_traces(opacity=.6)
    return fig

if __name__ == "__main__":
    app.run_server(mode="inline")
```

This sets the list of options (column names from the DataFrame) and the default selection

This passes the list of selected columns into the "x" argument of the histogram, plotting each one



CHECKLISTS

Checklists provide a list of options for the user to select (or *multi-select*)

- `dcc.Checklist(id, options, value)`

Basic
Interactivity

Interactive
Elements

Multiple Input
Callbacks

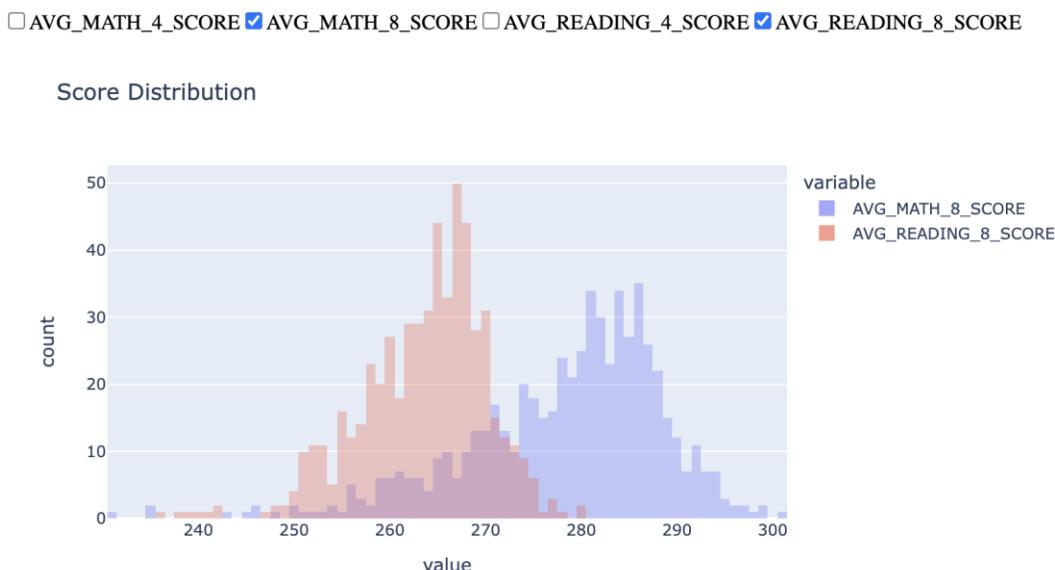
Multiple Output
Callbacks

```
app = JupyterDash(__name__)

app.layout = html.Div([
    dcc.Checklist(
        id="scores",
        options=[
            "AVG_MATH_4_SCORE",
            "AVG_MATH_8_SCORE",
            "AVG_READING_4_SCORE",
            "AVG_READING_8_SCORE"
        ],
        value=["AVG_MATH_4_SCORE"]
    ),
    dcc.Graph(id="graph")
])

@app.callback(
    Output("graph", "figure"),
    Input("scores", "value")
)
def plot_rev_hist(scores):
    fig = px.histogram(
        education,
        x=scores,
        barmode="overlay",
        title="Score Distribution"
    ).update_traces(opacity=.6)
    return fig

if __name__ == "__main__":
    app.run_server(mode="inline")
```



PRO TIP: Checklists are great for 2-8 options at a time, but beyond that can add significant clutter – consider a multi-select dropdown if you need more!

ASSIGNMENT: CHECKLISTS

 NEW MESSAGE
March 20, 2023

From: Leonard Lift (Ski Trip Concierge)
Subject: Park Features Map

Thanks for the help with the Map earlier!

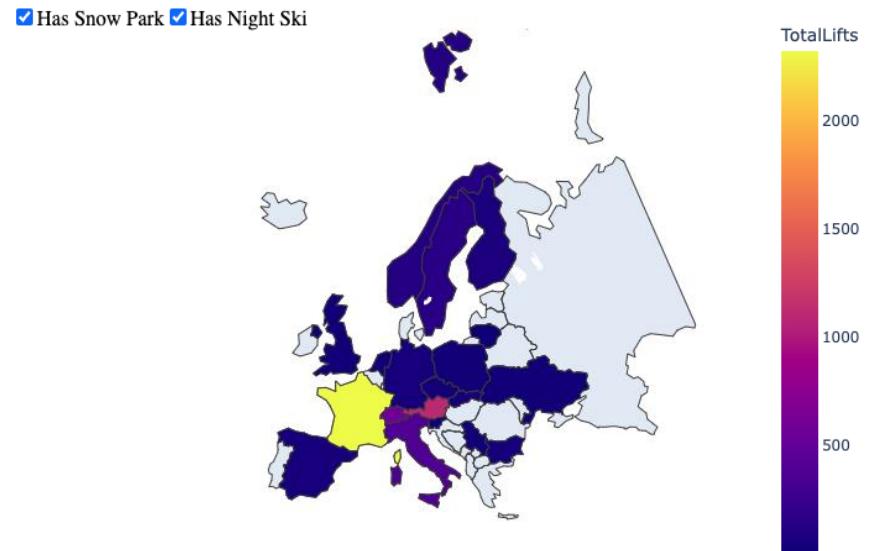
Can you add a checklist that allows me to filter down to ski resorts that have Snow Parks, Night Skiing or both?

Will be really helpful to pinpoint which countries make the best destinations for clients looking for specific experiences.

Thanks!

 Reply  Forward

Results Preview



SOLUTION: CHECKLISTS

 NEW MESSAGE
March 20, 2023

From: Leonard Lift (Ski Trip Concierge)
Subject: Park Features Map

Thanks for the help with the Bar Chart earlier!

Can you add a checklist that allows me to filter out whether ski resorts have Snow Parks, Night Skiing or both?

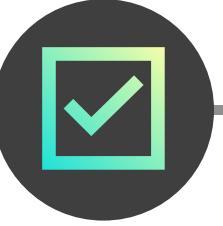
Will be really helpful to pinpoint which countries make the best destinations for clients looking for specific experiences.

Thanks!

 section03_solutions.ipynb  Reply  Forward

Solution Code

```
dcc.Checklist(  
    id="Feature Checklist",  
    options=[ "Has Snow Park", "Has Night Ski"],  
    value=[ "Has Snow Park", "Has Night Ski"],  
)
```



RADIO BUTTONS

Basic
Interactivity

Interactive
Elements

Multiple Input
Callbacks

Multiple Output
Callbacks

Radio buttons provide a list of options for the user to toggle between

- `dcc.RadioItems(id, options, value)`

```
app = JupyterDash(__name__)

app.layout = html.Div([
    dcc.RadioItems(
        id="OLS Toggle",
        options=["Trendline On", "Trendline Off"],
        value="Trendline Off"
    ),
    dcc.Graph(id="graph"),
])

@app.callback(
    Output('graph', 'figure'),
    Input("OLS Toggle", "value"),
)

def plot_rev_scatter(ols):
    fig = px.scatter(
        education,
        x="expenditure_per_student",
        y="AVG_MATH_8_SCORE",
        trendline=None if ols == "Trendline Off" else "ols",
        title = "The Relationship Between Spending and Test Scores",
    )
    return fig

if __name__ == "__main__":
    app.run_server(mode="inline", debug=True)
```

This sets the two options for the user to choose between, and sets the default

This adds an “ols” trendline if the selection is not “Trendline Off”



RADIO BUTTONS

Basic
Interactivity

Interactive
Elements

Multiple Input
Callbacks

Multiple Output
Callbacks

Radio buttons provide a list of options for the user to toggle between

- `dcc.RadioItems(id, options, value)`

```
app = JupyterDash(__name__)

app.layout = html.Div([
    dcc.RadioItems(
        id="OLS Toggle",
        options=["Trendline On", "Trendline Off"],
        value="Trendline Off"
    ),
    dcc.Graph(id="graph"),
])

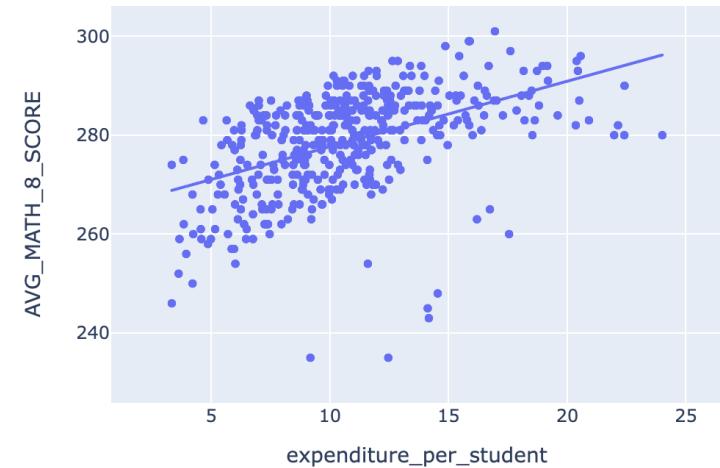
@app.callback(
    Output('graph', 'figure'),
    Input("OLS Toggle", "value"),
)

def plot_rev_scatter(ols):
    fig = px.scatter(
        education,
        x="expenditure_per_student",
        y="AVG_MATH_8_SCORE",
        trendline=None if ols == "Trendline Off" else "ols",
        title = "The Relationship Between Spending and Test Scores",
    )
    return fig

if __name__ == "__main__":
    app.run_server(mode="inline", debug=True)
```

● Trendline On ○ Trendline Off

The Relationship Between Spending and Test Scores





SLIDERS

Basic
Interactivity

Interactive
Elements

Multiple Input
Callbacks

Multiple Output
Callbacks

Sliders let users drag a handle to select a value inside a defined range

- `dcc.Slider(min, max, step, value)`

```
app = JupyterDash(__name__)

app.layout = html.Div([
    dcc.Slider(id="spend", min=0, max=30, step=5, value=15),
    dcc.Graph(id="graph"),
])

@app.callback(Output('graph', 'figure'), Input("spend", "value"))

def bar_chart(spending):
    fig = px.bar(
        education
        .query("expenditure_per_student > @spending")
        .groupby("YEAR", as_index=False)
        .count(),
        x="YEAR",
        y="expenditure_per_student",
        title=f"States that spent over ${spending}K per student"
    )
    fig.update_yaxes(title="COUNT", range=[0, 50])
    fig.update_xaxes(range=[1991, 2017])
    return fig

if __name__ == "__main__":
    app.run_server(mode="inline", debug=True)
```

This starts the slider at 15 and lets the user select values between 0-30 in 5-step intervals

This filters the DataFrame for “expenditures per student” greater than the selected value, groups the results by year, and plots the number of rows (States) in a bar chart



PRO TIP: These often align with Boolean operators, where users select options equal to, less than, or greater than some value

SLIDERS



Basic
Interactivity

Interactive
Elements

Multiple Input
Callbacks

Multiple Output
Callbacks

Sliders let users drag a handle to select a value inside a defined range

- `dcc.Slider(min, max, step, value)`

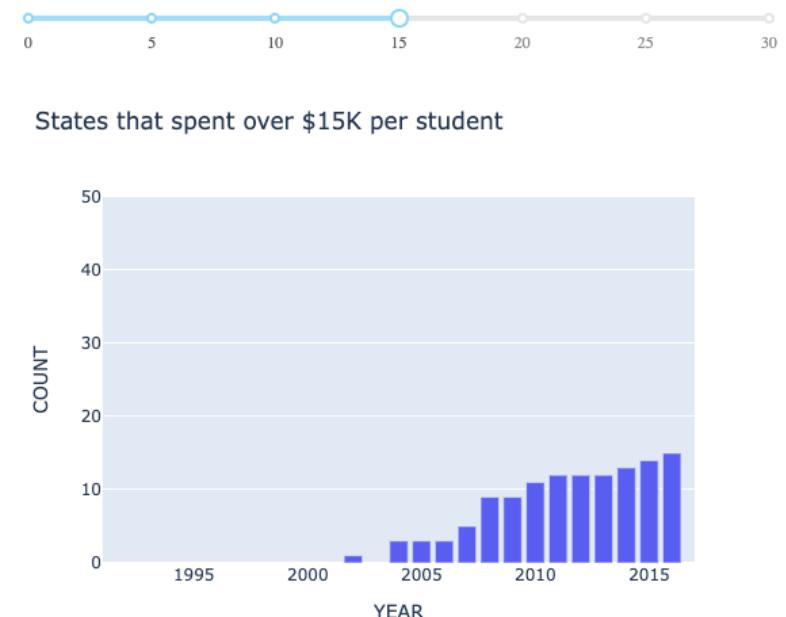
```
app = JupyterDash(__name__)

app.layout = html.Div([
    dcc.Slider(id="spend", min=0, max=30, step=5, value=15),
    dcc.Graph(id="graph"),
])

@app.callback(Output('graph', 'figure'), Input("spend", "value"))

def bar_chart(spending):
    fig = px.bar(
        education
        .query("expenditure_per_student > @spending")
        .groupby("YEAR", as_index=False)
        .count(),
        x="YEAR",
        y="expenditure_per_student",
        title=f"States that spent over ${spending}K per student"
    )
    fig.update_yaxes(title="COUNT", range=[0, 50])
    fig.update_xaxes(range=[1991, 2017])
    return fig

if __name__ == "__main__":
    app.run_server(mode="inline", debug=True)
```





RANGE SLIDERS

Basic
Interactivity

Interactive
Elements

Multiple Input
Callbacks

Multiple Output
Callbacks

Range sliders let users drag two handles to select a range of values

- `dcc.RangeSlider(min, max, step, value)`

```
app = JupyterDash(__name__)

app.layout = html.Div([
    dcc.RangeSlider(id="spend", min=0, max=30, step=5, value=[10,15]),
    dcc.Graph(id="graph"),
])

@app.callback(Output('graph', 'figure'), Input("spend", "value"))

def bar_chart(spending):
    fig = px.bar(
        education
        .query("@spending[0] <= expenditure_per_student <= @spending[1]")
        .groupby("YEAR", as_index=False)
        .count(),
        x="YEAR",
        y="expenditure_per_student",
        title=f"States that spent between ${spending[0]}-{spending[1]}K per student"
    )
    fig.update_yaxes(title="COUNT", range=[0, 50])
    fig.update_xaxes(range=[1991, 2017])
    return fig

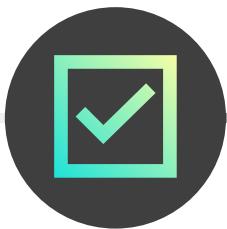
if __name__ == "__main__":
    app.run_server(mode="inline", debug=True)
```

This sets a list (or tuple) as the value

This filters the DataFrame using the `.between()` method instead of a Boolean operator
(Note that the values are accessed with their index)



PRO TIP: Range Sliders let you perform “between” selections rather than single value or single directions selections (like with traditional sliders)



RANGE SLIDERS

Basic
Interactivity

Interactive
Elements

Multiple Input
Callbacks

Multiple Output
Callbacks

Range sliders let users drag two handles to select a range of values

- `dcc.RangeSlider(min, max, step, value)`

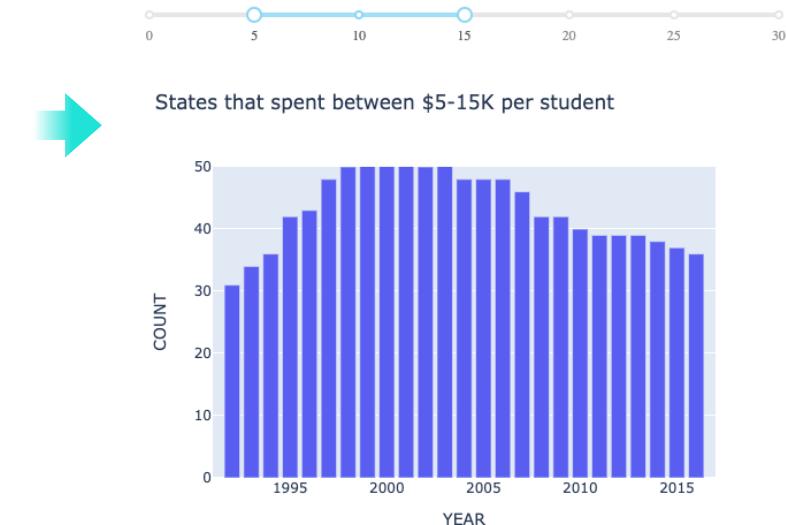
```
app = JupyterDash(__name__)

app.layout = html.Div([
    dcc.RangeSlider(id="spend", min=0, max=30, step=5, value=[10,15]),
    dcc.Graph(id="graph"),
])

@app.callback(Output('graph', 'figure'), Input("spend", "value"))

def bar_chart(spending):
    fig = px.bar(
        education
            .query("@spending[0] <= expenditure_per_student <= @spending[1]")
            .groupby("YEAR", as_index=False)
            .count(),
        x="YEAR",
        y="expenditure_per_student",
        title=f"States that spent between ${spending[0]}-{spending[1]}K per student"
    )
    fig.update_yaxes(title="COUNT", range=[0, 50])
    fig.update_xaxes(range=[1991, 2017])
    return fig

if __name__ == "__main__":
    app.run_server(mode="inline", debug=True)
```



ASSIGNMENT: SLIDERS

 NEW MESSAGE
March 23, 2023

From: **Leonard Lift** (Ski Trip Concierge)
Subject: **Elevation Selector**

Ok,
I'd like to update another visual you created before with interactivity.
Some of our customers love to get HIGH (in terms of elevation, of course).
Can you build a bar chart that shows number of ski resorts by country based on the elevation users select?
Thanks!

 Reply  Forward



SOLUTION: SLIDERS

 NEW MESSAGE
March 23, 2023

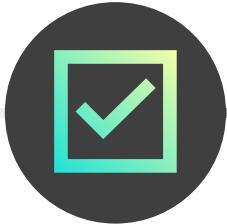
From: **Leonard Lift** (Ski Trip Concierge)
Subject: Elevation Selector

Ok,
I'd like to update another visual you created before with interactivity.
Some of our customers love to get HIGH (in terms of elevation, of course).
Can you build a bar chart that shows number of ski resorts by country based on the elevation users select?
Thanks!

 section03_solutions.ipynb  Reply  Forward

Solution Code

```
dcc.Slider(  
    id="Elevation Slider",  
    min=0,  
    max=4000,  
    value=500,  
    step=1000,  
    marks={i: f'{i}' for i in range(0, 4000, 500)}  
,
```



DATE PICKERS

Basic Interactivity

Interactive Elements

Multiple Input Callbacks

Multiple Output Callbacks

Date pickers let users select a date from a calendar drop down

- `dcc.DatePickerSingle(id, min_date_allowed, max_date_allowed, initial_visible_month, date, display_format)`

collisions.head()			
	DATE	BOROUGH	COLLISIONS
0	2012-07-01	BRONX	39
1	2012-07-01	BROOKLYN	135
2	2012-07-01	MANHATTAN	119
3	2012-07-01	QUEENS	101
4	2012-07-01	STATEN ISLAND	26

```
app = JupyterDash(__name__)

app.layout = html.Div([
    dcc.DatePickerSingle(
        id="date picker",
        min_date_allowed=collisions["DATE"].min(),
        max_date_allowed=collisions["DATE"].max(),
        initial_visible_month=collisions["DATE"].max(),
        date=collisions["DATE"].max(),
        display_format="YYYY-MM-DD"
    ),
    dcc.Graph(id="graph")
])

@app.callback(Output("graph", "figure"), Input("date picker", "date"))
def plot_collisions_bar(date):
    fig = px.bar(
        collisions.loc[collisions["DATE"].eq(date)],
        x="COLLISIONS",
        y="BOROUGH",
        title=f"Traffic Accidents in NYC on {date}"
    )
    return fig

if __name__ == "__main__":
    app.run_server(mode="inline")
```

This sets the min/max dates in the calendar from the data, and sets the max date as the starting value

Note that the input property is "date", not "value"

This plots the collisions for the selected date on a bar chart by borough



DATE PICKERS

Basic
Interactivity

Interactive
Elements

Multiple Input
Callbacks

Multiple Output
Callbacks

Date pickers let users select a date from a calendar drop down

- dcc.DatePickerSingle(id, min_date_allowed, max_date_allowed, initial_visible_month, date, display_format)

```
app = JupyterDash(__name__)

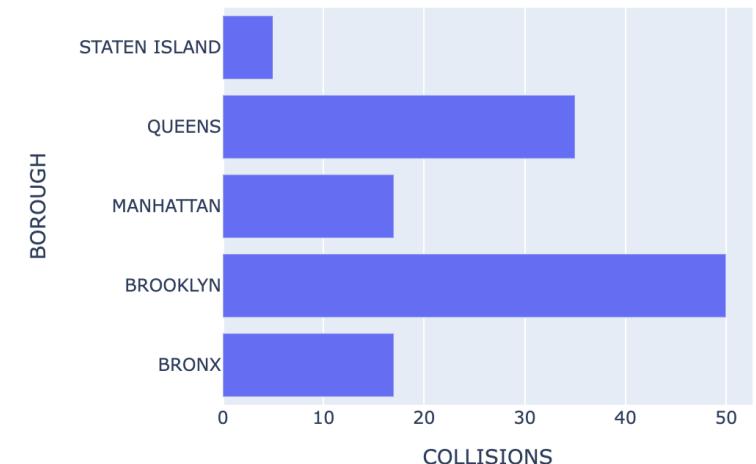
app.layout = html.Div([
    dcc.DatePickerSingle(
        id="date_picker",
        min_date_allowed=collisions["DATE"].min(),
        max_date_allowed=collisions["DATE"].max(),
        initial_visible_month=collisions["DATE"].max(),
        date=collisions["DATE"].max(),
        display_format="YYYY-MM-DD"
    ),
    dcc.Graph(id="graph")
])

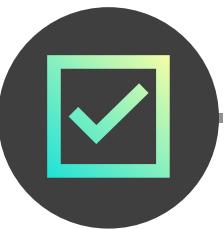
@app.callback(Output("graph", "figure"), Input("date_picker", "date"))
def plot_collisions_bar(date):
    fig = px.bar(
        collisions.loc[collisions["DATE"].eq(date)],
        x="COLLISIONS",
        y="BOROUGH",
        title=f"Traffic Accidents in NYC on {date}"
    )
    return fig

if __name__ == "__main__":
    app.run_server(mode="inline")
```

2022-11-24

Traffic Accidents in NYC on 2022-11-24





DATE RANGE PICKERS

Basic
Interactivity

Interactive
Elements

Multiple Input
Callbacks

Multiple Output
Callbacks

Date range pickers let users select a range of dates from calendar drop downs

- `dcc.DatePickerRange(id, start_date, end_date, display_format)`

```
app = JupyterDash(__name__)

app.layout = html.Div([
    dcc.DatePickerRange(
        id="dates",
        start_date=collisions["DATE"].min(),
        end_date=collisions["DATE"].max(),
        display_format="YYYY-MM-DD"
    ),
    dcc.Graph(id="graph")
])

@app.callback(
    Output("graph", "figure"),
    [Input("dates", "start_date"), Input("dates", "end_date")]
)
def plot_rev_line(start, end):
    fig = px.line(
        collisions
        .loc[collisions["DATE"].between(start, end)]
        .groupby("DATE", as_index=False)
        .sum(),
        x="DATE",
        y="COLLISIONS",
        title=f"Traffic Accidents in NYC"
    )
    return fig

if __name__ == "__main__":
    app.run_server(mode="inline")
```

This sets the min/max dates in the data as the start/end dates for the calendar dropdowns

Note that **two inputs** are needed (they don't need to be in a list, but it keeps them organized)

This filters the "DATE" using the range selected, groups the DataFrame by "DATE", and sums the collisions, plotting them in a line chart



DATE RANGE PICKERS

Basic
Interactivity

Interactive
Elements

Multiple Input
Callbacks

Multiple Output
Callbacks

Date range pickers let users select a range of dates from calendar drop downs

- dcc.DatePickerRange(id, start_date, end_date, display_format)

```
app = JupyterDash(__name__)

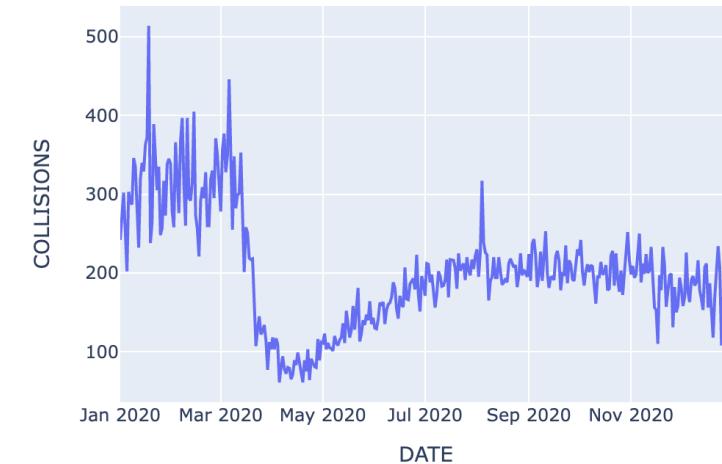
app.layout = html.Div([
    dcc.DatePickerRange(
        id="dates",
        start_date=collisions["DATE"].min(),
        end_date=collisions["DATE"].max(),
        display_format="YYYY-MM-DD"
    ),
    dcc.Graph(id="graph")
])

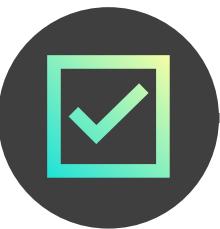
@app.callback(
    Output("graph", "figure"),
    [Input("dates", "start_date"), Input("dates", "end_date")]
)
def plot_rev_line(start, end):
    fig = px.line(
        collisions
        .loc[collisions["DATE"].between(start, end)]
        .groupby("DATE", as_index=False)
        .sum(),
        x="DATE",
        y="COLLISIONS",
        title=f"Traffic Accidents in NYC"
    )
    return fig

if __name__ == "__main__":
    app.run_server(mode="inline")
```

2020-01-01 → 2020-12-31

Traffic Accidents in NYC





MULTIPLE INPUT CALLBACKS

A single callback function can have **multiple inputs**

- This lets you add multiple interactive elements to the same application!

Basic
Interactivity

Interactive
Elements

Multiple Input
Callbacks

Multiple Output
Callbacks

```
app = JupyterDash(__name__)

app.layout = html.Div([
    dcc.Dropdown(
        id="x_column",
        options=list(education.select_dtypes(include="number").columns),
        value="expenditure_per_student"
    ),
    dcc.Dropdown(
        id="y_column",
        options=list(education.select_dtypes(include="number").columns),
        value="AVG_MATH_8_SCORE"
    ),
    dcc.Graph(id="graph")
])

@app.callback(
    Output("graph", "figure"),
    Input("x_column", "value"),
    Input("y_column", "value")
)
def plot_rev_scatter(x, y):
    fig = px.scatter(
        education,
        x=x,
        y=y,
        trendline="ols"
    )
    return fig

if __name__ == "__main__":
    app.run_server(mode="inline")
```

This creates **two dropdowns** for the user to select DataFrame columns with

Note that **two inputs** are needed, and they are passed into the function in the same order

This sets the “x” and “y” variables for the scatterplot using the selections



MULTIPLE INPUT CALLBACKS

A single callback function can have **multiple inputs**

- This lets you add multiple interactive elements to the same application!

Basic
Interactivity

Interactive
Elements

Multiple Input
Callbacks

Multiple Output
Callbacks

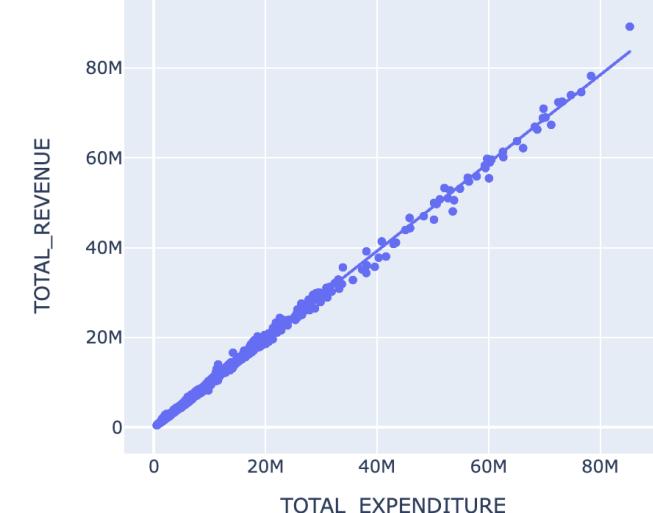
```
app = JupyterDash(__name__)

app.layout = html.Div([
    dcc.Dropdown(
        id="x_column",
        options=list(education.select_dtypes(include="number").columns),
        value="expenditure_per_student"
    ),
    dcc.Dropdown(
        id="y_column",
        options=list(education.select_dtypes(include="number").columns),
        value="AVG_MATH_8_SCORE"
    ),
    dcc.Graph(id="graph")
])

@app.callback(
    Output("graph", "figure"),
    Input("x_column", "value"),
    Input("y_column", "value")
)
def plot_rev_scatter(x, y):
    fig = px.scatter(
        education,
        x=x,
        y=y,
        trendline="ols"
    )
    return fig

if __name__ == "__main__":
    app.run_server(mode="inline")
```

TOTAL_EXPENDITURE
TOTAL_REVENUE





MULTIPLE OUTPUT CALLBACKS

A single callback function can also return **multiple outputs**

- This can help modify text or multiple charts with a single interactive element (or several!)

Basic Interactivity

Interactive Elements

Multiple Input Callbacks

Multiple Output Callbacks

```
app = JupyterDash(__name__)

app.layout = html.Div([
    html.H2(id="header"),
    dcc.Dropdown(
        id="x_column",
        options=list(education.select_dtypes(include="number").columns),
        value="expenditure_per_student"
    ),
    dcc.Dropdown(
        id="y_column",
        options=list(education.select_dtypes(include="number").columns),
        value="AVG_MATH_8_SCORE"
    ),
    dcc.Graph(id="graph")
])

@app.callback(
    Output("header", "children"),
    Output("graph", "figure"),
    Input("x_column", "value"),
    Input("y_column", "value")
)
def plot_rev_scatter(x, y):
    fig = px.scatter(
        education,
        x=x,
        y=y,
        trendline="ols"
    )
    header = f"{x.title().replace('_', ' ')} vs {y.title().replace('_', ' ')}"
    return header, fig

if __name__ == "__main__":
    app.run_server(mode="inline")
```

This creates an empty header to be updated by the callback function (at the same time as the graph)

Note that **two outputs** are used, one for the "graph" and the other for the "header"

The order must follow the order of the outputs!



MULTIPLE OUTPUT CALLBACKS

Basic
Interactivity

Interactive
Elements

Multiple Input
Callbacks

Multiple Output
Callbacks

```
app = JupyterDash(__name__)

app.layout = html.Div([
    html.H2(id="header"),
    dcc.Dropdown(
        id="x_column",
        options=list(education.select_dtypes(include="number").columns),
        value="expenditure_per_student"
    ),
    dcc.Dropdown(
        id="y_column",
        options=list(education.select_dtypes(include="number").columns),
        value="AVG_MATH_8_SCORE"
    ),
    dcc.Graph(id="graph")
])

@app.callback(
    Output("header", "children"),
    Output("graph", "figure"),
    Input("x_column", "value"),
    Input("y_column", "value")
)
def plot_rev_scatter(x, y):
    fig = px.scatter(
        education,
        x=x,
        y=y,
        trendline="ols"
    )
    header = f"{x.title().replace('_', ' ')} vs {y.title().replace('_', ' ')}"
    return header, fig

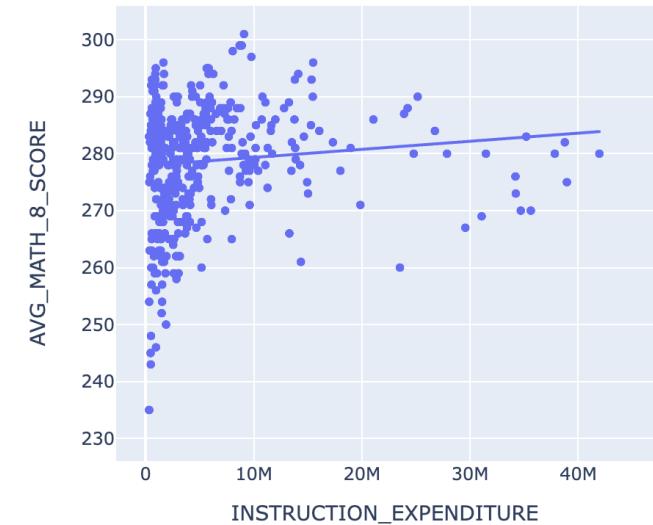
if __name__ == "__main__":
    app.run_server(mode="inline")
```

A single callback function can also return **multiple outputs**

- This can help modify text or multiple charts with a single interactive element (or several!)

Instruction Expenditure vs Avg Math 8 Score

INSTRUCTION_EXPENDITURE
X ▾
AVG_MATH_8_SCORE
X ▾



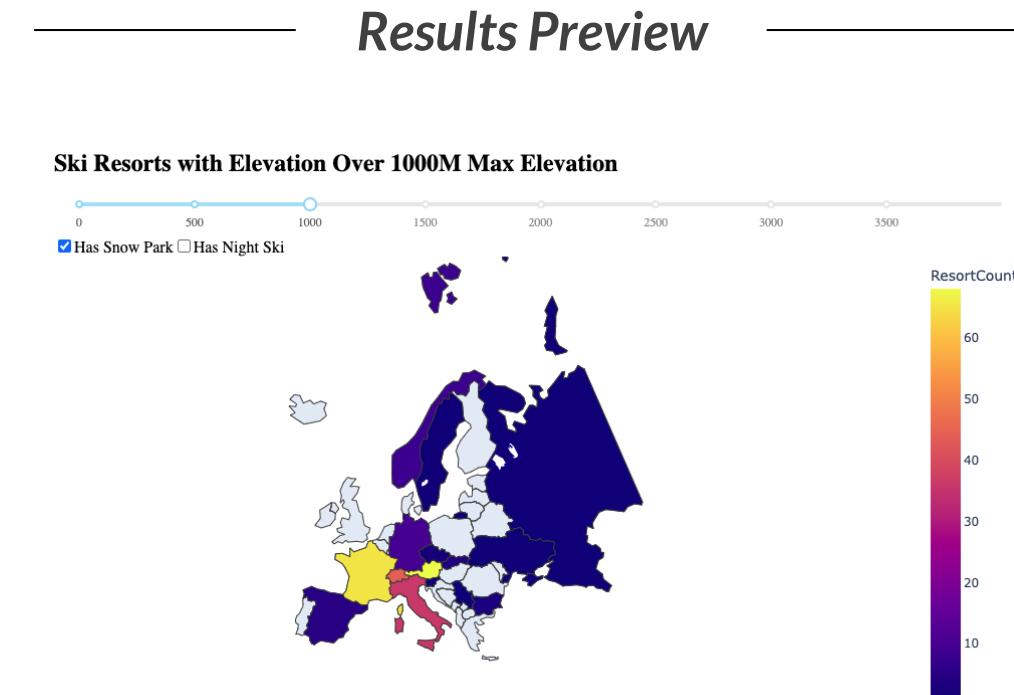
ASSIGNMENT: MULTIPLE INTERACTIVE ELEMENTS

 NEW MESSAGE
March 25, 2023

From: **Leonard Lift** (Ski Trip Concierge)
Subject: Single Map Feature View

Hey there,
Can we apply the elevation slider to the map-based view?
It's much more helpful given we're working with geographic areas (please keep the Snow Park & Night Ski checklist in the same map too!)
If you're daring, try to embed the elevation selected in the header of the chart as well!
Thanks!

 Reply  Forward



SOLUTION: MULTIPLE INTERACTIVE ELEMENTS

 NEW MESSAGE
March 25, 2023

From: **Leonard Lift** (Ski Trip Concierge)
Subject: Single Map Feature View

Hey there,

Can we apply the elevation slider to the map-based view?

It's much more helpful given we're working with geographic areas (please keep the Snow Park & Night Ski checklist in the same map too!)

If you're daring, try to embed the elevation selected in the header of the chart as well!

Thanks!

Solution Code

```
app.layout = html.Div([
    html.H2(id="title"),
    dcc.Slider(
        id="Elevation Slider",
        min=0,
        max=4000,
        step=500,
        marks={i: f'{i}' for i in range(0, 4000, 500)}
    ),
    dcc.Checklist(
        id="Feature Checklist",
        options=["Has Snow Park", "Has Night Ski"],
        value=["Has Snow Park", "Has Night Ski"],
    ),
    dcc.Graph(id="graph"),
])

@app.callback(
    Output('title', 'children'),
    Output('graph', 'figure'),
    Input("Elevation Slider", "value"),
    Input("Feature Checklist", "value"),
)
```

KEY TAKEAWAYS



Dash has a wide range of **interactive elements** you can use in apps

- *Choose the right one by considering the data types, number of options, and filtering criteria (logical comparisons)*



Use dropdowns, checklists, and radio buttons for **categories**

- *Checklists and radio buttons are great for a limited number of options, while dropdown menus can incorporate dozens while keeping your applications compact*



Use sliders and date pickers for **numbers & dates**

- *Singe value sliders and date pickers work well with inequalities, while range options are best for “between” logic*



Callback functions can have **multiple inputs & outputs**

- *Multiple outputs let you modify several visuals or text using a single interactive element*
- *Multiple inputs let you use several interactive elements to modify text and visuals in your app*

MID-COURSE PROJECT

PROJECT DATA: US & CANADA RESORTS

resorts.head()

ID	Resort	Latitude	Longitude	Country	Continent	Price	Season	Highest point	Lowest point	...	Snow cannons	Surface lifts	Chair lifts	Gondola lifts	Total lifts	Lift capacity
0	Red Mountain Resort-Rossland	49.105520	-117.846280	Canada	North America	60	December - April	2075	1185	...	0	2	5	1	8	9200
1	Fernie	49.504175	-115.062867	Canada	North America	67	December - April	2134	1052	...	11	3	7	0	10	14514
2	Sun Peaks	50.884468	-119.882329	Canada	North America	62	November - April	2082	1198	...	0	6	6	0	12	13895
3	Panorama	50.736999	-119.120561	Canada	North America	62	December - April	2365	1140	...	0	3	6	4	13	11890
4	Steamboat	35.754022	-109.853751	United States	North America	120	November - April	3221	2103	...	0	1	14	2	17	32720

5 rows × 25 columns



MAVELUXE

resorts.info()

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 98 entries, 0 to 97
Data columns (total 25 columns):
 #   Column           Non-Null Count  Dtype  
--- 
 0   ID               98 non-null      int64  
 1   Resort            98 non-null      object  
 2   Latitude          98 non-null      float64 
 3   Longitude         98 non-null      float64 
 4   Country           98 non-null      object  
 5   Continent         98 non-null      object  
 6   Price             98 non-null      int64  
 7   Season            98 non-null      object  
 8   Highest point     98 non-null      int64  
 9   Lowest point      98 non-null      int64  
 10  Beginner slopes   98 non-null      int64  
 11  Intermediate slopes  98 non-null      int64  
 12  Difficult slopes  98 non-null      int64  
 13  Total slopes      98 non-null      int64  
 14  Longest run       98 non-null      int64  
 15  Snow cannons       98 non-null      int64  
 16  Surface lifts     98 non-null      int64  
 17  Chair lifts        98 non-null      int64  
 18  Gondola lifts      98 non-null      int64  
 19  Total lifts        98 non-null      int64  
 20  Lift capacity      98 non-null      int64  
 21  Child friendly     98 non-null      object  
 22  Snowparks          98 non-null      object  
 23  Nightskiing        98 non-null      object  
 24  Summer skiing      98 non-null      object  
dtypes: float64(2), int64(15), object(8)
memory usage: 19.3+ KB
```

ASSIGNMENT: MIDCOURSE PROJECT

 **NEW MESSAGE**
March 28, 2023

From: Deepthi Downhill (VP of Analytics)
Subject: More Ambitious Ski Resort App

Hello,

The work you've been doing with Leonard is very exciting. This type of application can save our agents hundreds of hours annually! I want to applaud you both on this amazing initiative.

That said, it's time to think a bit bigger. While Europe is a solid market, it's behind the US and Canada for us given our customers are almost exclusively from North America. Can you create two apps that will help us with these markets?

Thanks!

 section04_midcourse_project.ipynb  Reply  Forward

Key Objectives

1. Build two working Dash Applications
2. Add multiple chart types and interactive elements
3. Connect them with callback functions capable of taking multiple inputs and returning multiple outputs



DASHBOARD LAYOUTS

DASHBOARD LAYOUTS



In this section we'll introduce dashboard design principles and build **dashboard layouts** in Dash, including some more advanced HTML and the Dash Bootstrap Components library

TOPICS WE'LL COVER:

Dashboard Basics

HTML Layouts

App Styling

Dash Bootstrap Components

GOALS FOR THIS SECTION:

- Identify the types of dashboards, their key elements, and design principles for effective dashboard layouts
- Create dashboard layouts using HTML, markdown, and Dash Bootstrap Components
- Add custom formatting to layouts using themes or by styling each component individually



DASHBOARDS 101

Dashboard Basics

HTML Layouts

App Styling

Dash Bootstrap Components

Dashboards are groups of visuals that help understand data and make decisions

- They can be used for both **exploratory** and **explanatory** analysis



EXPLORATORY

- Goal is to **explore and profile** the data to see what insights emerge
- Helps you understand the data and identify interesting patterns & trends



EXPLANATORY

- Goal is to **tell a specific story** or explain what happened and why
- Identifies key business drivers and delivers insights & recommendations



We'll mostly focus on dashboards for **exploratory analysis** in this course, but you can check out our Data Visualization with Matplotlib & Seaborn for good explanatory examples



DASHBOARD ELEMENTS

Dashboard Basics

HTML Layouts

App Styling

Dash Bootstrap Components

There are two main types of **dashboard elements**:

1

Metrics & visuals

- What are the main metrics (KPIs) the dashboard needs to track?
- What other metrics add context to complement these?
- What chart type is appropriate to visualize each metric?

2

Filters & interactivity

- Will users need to see specific, filtered views?
- Will they need to drill up or down to different levels of granularity?



PRO TIP: Think like a **business owner** before you think like an analyst; before you begin building your dashboard with code, take time to understand the outcomes you're trying to impact, the key stakeholders and their motivations, and the specific purpose your dashboard will serve



DASHBOARD LAYOUTS

Dashboard Basics

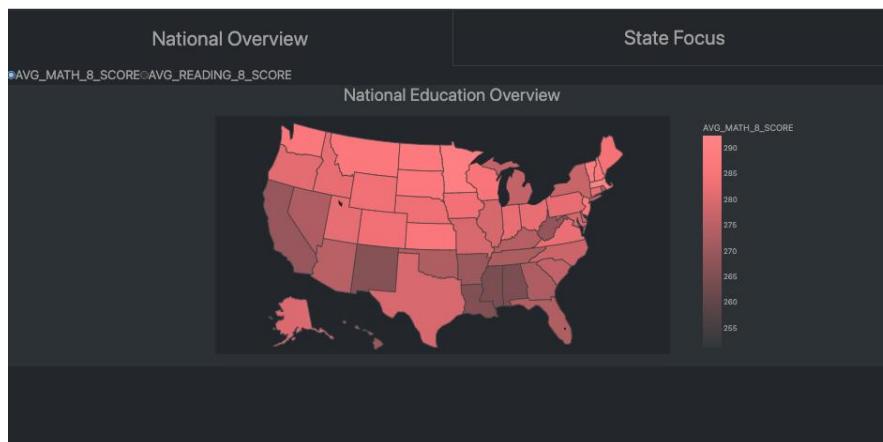
HTML Layouts

App Styling

Dash Bootstrap Components

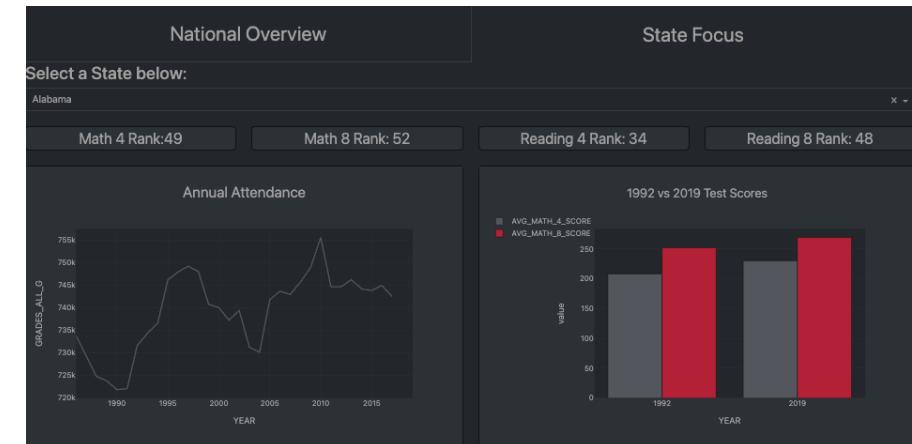
A strong **dashboard layout** adds cohesion to its visuals & interactivity, drawing attention to key metrics and guiding the viewer through a logical progression

First tab



Nationwide view of test performance and other KPIs

Second tab



State-level deep dive with context on relative ranks



PRO TIP: Design your dashboard layout like an **inverse pyramid**; the most important metrics and visuals should come first, followed by any supporting data or more granular views

KPIs

Fine detail



RECAP: HTML LAYOUTS

Dashboard Basics

HTML Layouts

App Styling

Dash Bootstrap Components

Dash uses **HTML layouts** for designing the front-end of the application

- Use the **html** module to specify the visual components and assign it to **app.layout**

```
app.layout = html.Div([
    html.H2(id="header"),
    html.P("Select a State Below"),
    dcc.Dropdown(options=["Alabama"], id="State Dropdown"),
    dcc.Graph(id="Enrollment Line"),
    html.P("Important footnote about this data")
])
```

The **html.Div** works as a container for its “children”, which can be **html** or **dcc** components



Styles specified for **html** Divs will **cascade to standard html elements** within them, but **dcc** components override these styles by default (more on this later!)



RECAP: HTML LAYOUTS

Dashboard Basics

HTML Layouts

App Styling

Dash Bootstrap Components

Dash uses **HTML layouts** for designing the front-end of the application

- Use the **html** module to specify the visual components and assign it to **app.layout**

```
app.layout = html.Div([
    html.H2(id="header"),
    html.P("Select a State Below"),
    dcc.Dropdown(options=["Alabama"], id="State Dropdown"),
    dcc.Graph(id="Enrollment Line"),
    html.P("Important footnote about this data")
])
```

 *The html module writes html code for us!*

```
▼<div id="_dash-app-content">
  ▼<div>
    <h2 id="header">Total Enrollment Tax Revenue in Alabama</h2>
    <p>Select a State Below</p>
    ▶<div id="State Dropdown" class="dash-dropdown">...</div>
    ▶<div id="Enrollment Line" class="dash-graph">...</div>
    <p>Important footnote about this data</p>
```

Total Enrollment Tax Revenue in Alabama

Select a State Below

Alabama



Important footnote about this data



HTML COMPONENT CHEATSHEET

Dashboard Basics

HTML Layouts

App Styling

Dash Bootstrap Components

Component	Description
html.Div()	A web page section (you can use multiple Divs to create sections with different styles)
html.H1(), H2(), ..., H6()	Different sized headers used to denote hierarchy or importance (more so than size itself)
html.P()	A paragraph, or generic body text, often smaller than and placed immediately below a header
html.Span()	Inline containers used to apply different colors or styles to text within headers or paragraphs

```
app.layout = html.Div([
    html.H1("This is a Header"),
    html.H2("This is a Header"),
    html.H3("This is a Header"),
    html.H4("This is a Header"),
    html.H5("This is a Header"),
    html.H6("This is a Header"),
    html.P([
        "This is a ",
        html.Span("Paragraph", style={"color": "red"}),
        html.Span(", or body text.")
    ])
])
```

This is a Header

This is a Paragraph, or body text.





PRO TIP: MARKDOWN

Dashboard Basics

HTML Layouts

App Styling

Dash Bootstrap Components

You can also use `dcc.Markdown()` to embed text into the front-end of your app

```
app.layout = html.Div([
    dcc.Markdown('''
        # One Hash is the biggest header.
        ## Two Hashes is smaller
        ### Three is even smaller
        ##### Four... and so on
        ##### Five... and so on
        ##### Until six, which is the smallest

        Type without hashes for body text.

        * Asterisks
        * For
        * Bullets

        1. Number and Period
        2. For Numbered Lists

        *italic* **bold** ***bold and italic***
    ''')
])
```

One Hash is the biggest header.

Two Hashes is smaller

Three is even smaller

Four... and so on

Five... and so on

Until six, which is the smallest

Type without hashes for body text.

- Asterisks
- For
- Bullets

1. Number and Period 2. For Numbered Lists

italic* **bold** ***bold and italic**



PRO TIP: Markdown is easier to write and more convenient for things like modifying font weight and building lists than HTML – it's a bit harder to style, but generally more than sufficient for most apps!

ASSIGNMENT: HTML & MARKDOWN

 NEW MESSAGE
April 1, 2023

From: **Leonard Lift** (Ski Trip Concierge)
Subject: **HTML?**

Hey there,
Are you familiar with HTML?
I was talking to our designer who is slammed, but I don't want to delay – can you send me a basic HTML layout to show what you can do?
If it's decent, we can move forward with styling our app.
More details in the notebook!
Thanks!

 Section05_assignments.ipynb  Reply  Forward

Results Preview

Hello!!!

Welcome to the **BEST** website in the world!

Section 1

Shopping List

- Apples
- Salad Tongs
- Jumbo Couch

Note to self: Don't forget to bring shopping bag!

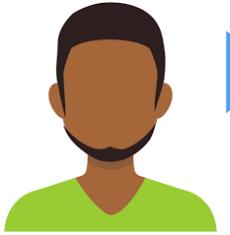
Section 2

Learning List

1. Python
2. More Python
3. A bit of HTML

Note to self: Be kind to yourself if you get stuck.

SOLUTION: HTML & MARKDOWN

 NEW MESSAGE
April 1, 2023

From: **Leonard Lift** (Ski Trip Concierge)
Subject: **HTML?**

Hey there,
Are you familiar with HTML?
I was talking to our designer who is slammed, but I don't want to delay – can you send me a basic HTML layout to show what you can do?
If it's decent, we can move forward with styling our app.
More details in the notebook!
Thanks!

 Section05_solutions.ipynb  Reply  Forward

Solution Code

```
app.layout = html.Div(  
    style={  
        "font-family": "Arial",  
        "backgroundColor": "black",  
        "color": "lightGrey",  
        "horizontal-align": "center"  
    },  
    children=[  
        html.H1("Hello!!!"),  
        html.P(  
            ["Welcome to the ",  
             html.Span("BEST",  
                      style={  
                          "color": "Red", "font-weight": "Bold", "fontSize": 32  
                      }),  
             " website in the world!"  
        ),  
        html.Br(),  
        html.Div([  
            dcc.Markdown(''  
                # Section 1  
                ### Shopping List  
                * Apples  
                * Salad Tongs  
                * Jumbo Couch  
  
                **Note to self**: Don't forget to bring shopping bag!  
            ''),  
            html.Br(),  
            dcc.Markdown(''  
                # Section 2  
                ### Learning List  
                1. Python  
                2. More Python  
                3. A bit of HTML  
  
                **Note to self**: *Be kind to yourself if you get stuck.*  
            ''', style={"color": "limegreen"}  
        )  
    ])
```



STYLING HTML

Dashboard Basics

HTML Layouts

App Styling

Dash Bootstrap Components

You can **style HTML components** with the “style” argument

- This lets you modify things like font types, sizes, and colors, as well as the background color

```
app.layout = html.Div([
    html.H2(id="header"),
    html.P("Select a State Below"),
    dcc.Dropdown(options=[ "Alabama" ], id="State Dropdown"),
    dcc.Graph(id="Enrollment Line"),
    html.P("Important footnote about this data")
])
```

No style has been specified yet

The default style for Dash apps
and their components is black
text with white backgrounds

Total Enrollment Tax Revenue in Alabama

Select a State Below

Alabama

Alabama



Important footnote about this data



STYLING HTML

Dashboard Basics

HTML Layouts

App Styling

Dash Bootstrap Components

You can **style HTML components** with the “style” argument

- This lets you modify things like font types, sizes, and colors, as well as the background color

```
my_dash_app_style={  
    "color": "lightgrey",  
    "backgroundColor": "black",  
    "fontFamily": "Arial"  
}  
  
app.layout = html.Div(  
    style=my_dash_app_style,  
    children = [  
        html.H2(id="header"),  
        html.P("Select a State Below"),  
        dcc.Dropdown(options=[ "Alabama"], id="State Dropdown"),  
        dcc.Graph(id="Enrollment Line"),  
        html.P(  
            "Important footnote about this data",  
            style={"backgroundColor": "grey", "fontSize": 8}  
    ])
```

You can create a style dictionary in advance and assign it to a variable that can be reused in the app

Styles applied to an outer Div are passed through to (most) of its children – more on this later!

You can always apply a style to an individual html component directly to override any parent styles

This sets a light grey Arial font on a black background for the app components, except for the final paragraph (this has a grey background color with an absurdly small font size)



STYLING HTML

Dashboard Basics

HTML Layouts

App Styling

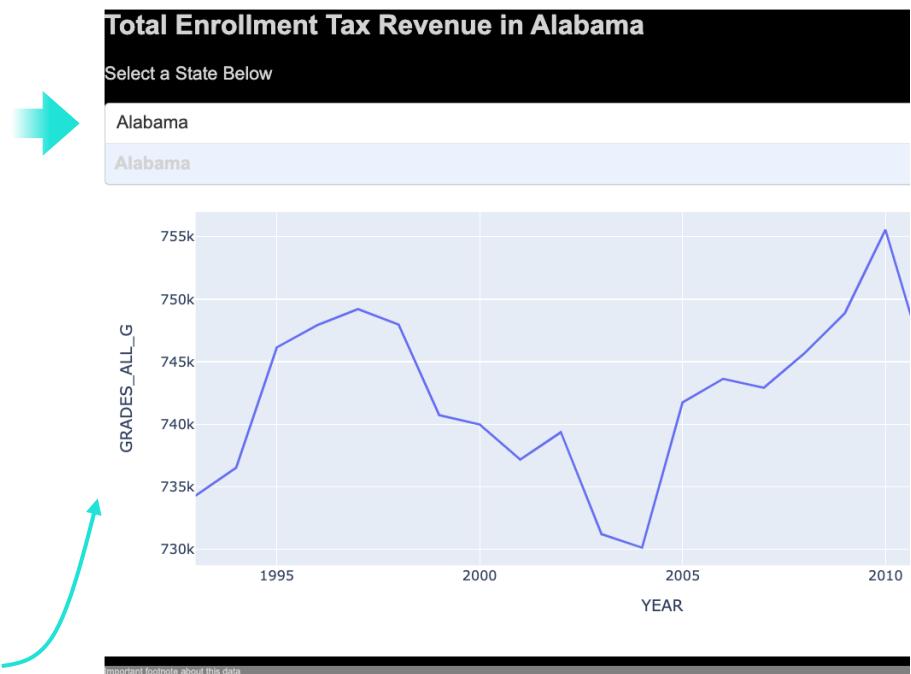
Dash Bootstrap Components

You can **style HTML components** with the “style” argument

- This lets you modify things like font types, sizes, and colors, as well as the background color

```
my_dash_app_style={  
    "color": "lightgrey",  
    "backgroundColor": "black",  
    "fontFamily": "Arial"  
}  
  
app.layout = html.Div(  
    style=my_dash_app_style,  
    children = [  
        html.H2(id="header"),  
        html.P("Select a State Below"),  
        dcc.Dropdown(options=[{"Alabama"}, id="State Dropdown"),  
        dcc.Graph(id="Enrollment Line"),  
        html.P(  
            "Important footnote about this data",  
            style={"backgroundColor": "grey", "fontSize": 8}  
        )  
    ]  
)
```

Note that the dropdown and chart
didn't inherit the parent style!





HTML STYLE CHEATSHEET

Dashboard Basics

HTML Layouts

App Styling

Dash Bootstrap Components

Argument	Examples
color	"red", "#FF0000"
backgroundColor	"red", "#FF0000"
fontSize	12, 14, 20
fontFamily	"Arial", "Calibri"
text-align	"center", "left", "right"



PRO TIP: Consider defining style dictionaries in advance to improve readability within the front-end code

```
disclaimer_style = {"color": "red", "fontSize": 12}
bluewhite_style = {
    "color": "white",
    "backgroundColor": "darkblue",
    "fontSize": 20,
    "fontFamily": "Microsoft Sans Serif",
    "text-align": "center"
}

app.layout = html.Div([
    html.P([
        "Defaults or Parent style applied if Style not specified.",  

        html.Span(
            "Spans apply different styles within an HTML element.",
            style=disclaimer_style
        ),
        html.P(
            "Here are all the basic properties specified.",
            style=bluewhite_style
        )
    ])
])
```

Defaults or Parent style applied if Style not specified. Spans apply different styles within an HTML element.

Here are all the basic properties specified.



STYLING DCC COMPONENTS

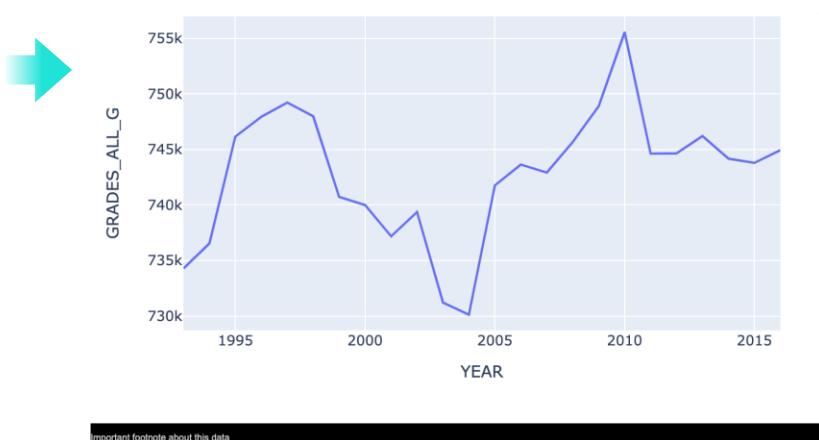
Dashboard Basics

HTML Layouts

App Styling

Dash Bootstrap Components

```
my_dash_app_style={  
    "color": "lightgrey",  
    "backgroundColor": "black",  
    "fontFamily": "Arial"  
}  
  
app.layout = html.Div(  
    style=my_dash_app_style,  
    children = [  
        html.H2(id="header"),  
        html.P("Select a State Below"),  
        dcc.Dropdown(  
            id="State Dropdown",  
            options=["ALABAMA", "ALASKA"],  
            value="ALABAMA",  
            style={  
                "color": "lightgrey",  
                "backgroundColor": "black"  
            }  
,  
        dcc.Graph(id="Enrollment Line"),  
        html.P(  
            "Important footnote about this data",  
            style={"fontSize": 8}  
    )  
])
```



The background is now black, but the expanded options are still white,

The font color is light grey, but the placeholder text is much darker



STYLING DCC COMPONENTS

Dashboard Basics

HTML Layouts

App Styling

Dash Bootstrap Components

```
my_dash_app_style={  
    "color": "lightgrey",  
    "backgroundColor": "black",  
    "fontFamily": "Arial"  
}  
  
app.layout = html.Div(  
    style=my_dash_app_style,  
    children = [  
        html.H2(id="header"),  
        html.P("Select a State Below"),  
        dcc.Dropdown(  
            id="State Dropdown",  
            options=[ "ALABAMA", "ALASKA "],  
            value="ALABAMA",  
            style=my_dash_app_style  
        ),  
        dcc.Graph(id="Enrollment Line"),  
        html.P(  
            "Important footnote about this data",  
            style={"fontSize": 8}  
        )  
])
```

You can simply call the style you have set



Important footnote about this data



STYLING DCC COMPONENTS

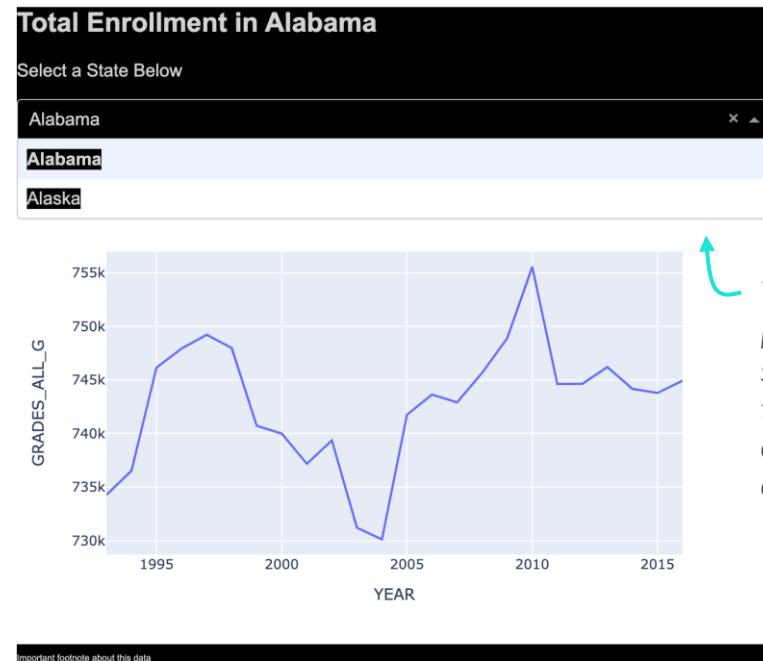
Dashboard Basics

HTML Layouts

App Styling

Dash Bootstrap Components

```
my_dash_app_style={  
    "color": "lightgrey",  
    "backgroundColor": "black",  
    "fontFamily": "Arial"  
}  
  
app.layout = html.Div(  
    style=my_dash_app_style,  
    children = [  
        html.H2(id="header"),  
        html.P("Select a State Below"),  
        dcc.Dropdown(  
            id="State Dropdown",  
            options=[  
                {"label": html.Span("Alabama", style=my_dash_app_style),  
                 "value": "ALABAMA"},  
                {"label": html.Span("Alaska", style=my_dash_app_style),  
                 "value": "ALASKA"}  
            ],  
            value="ALABAMA",  
            style={  
                "color": "lightgrey",  
                "backgroundColor": "black"  
            }  
        ),  
        dcc.Graph(id="Enrollment Line"),  
        html.P(  
            "Important footnote about this data",  
            style={"fontSize": 8}  
        )  
    ]  
)
```



The text colors are perfect after applying styles to each label, but the dropdown menu options are still white outside of the text!



DCC components are **deceptively difficult to style** because they are defined by Dash's CSS, but there are ways to get around this without needing to know CSS



FIGURE STYLING

Dashboard Basics

HTML Layouts

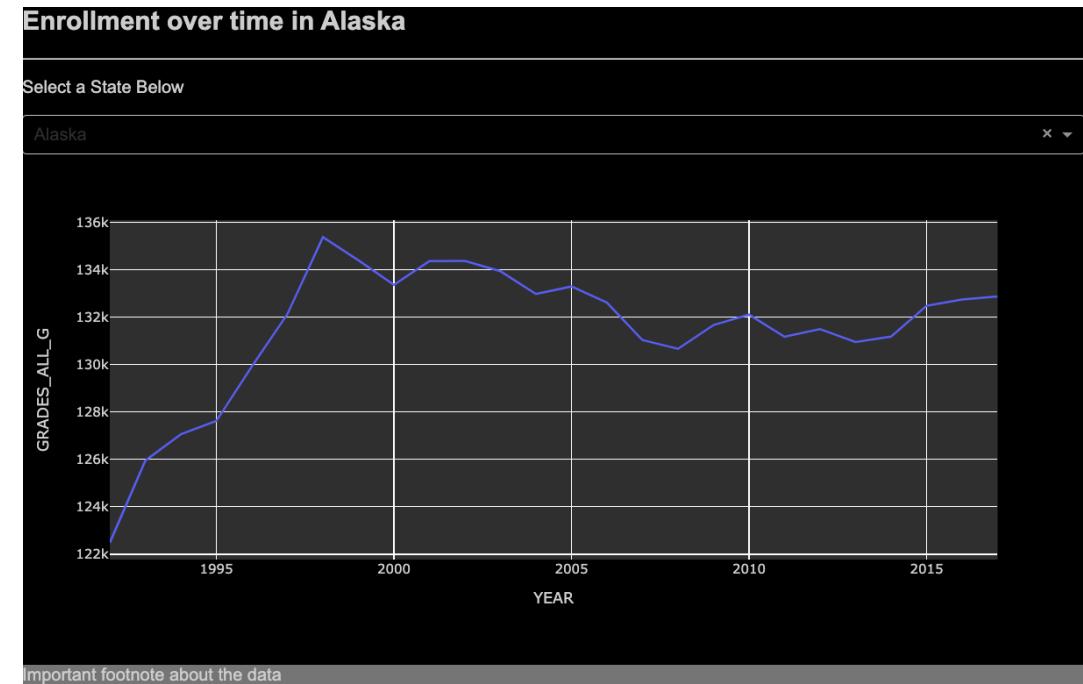
App Styling

Dash Bootstrap Components

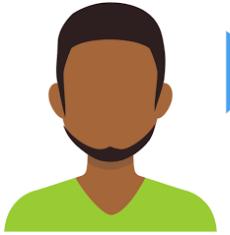
You need to **style Plotly figures** independently from HTML components

- You can use the `.update_layout()` method to modify the style to match the rest of the app

```
fig=px.line(  
    df,  
    x="YEAR",  
    y="GRADES_ALL_G",  
    title="Enrollment over Time"  
)  
.update_layout(  
    paper_bgcolor="black",  
    plot_bgcolor="#343634",  
    font_color="lightgrey"  
)
```



ASSIGNMENT: APP STYLING

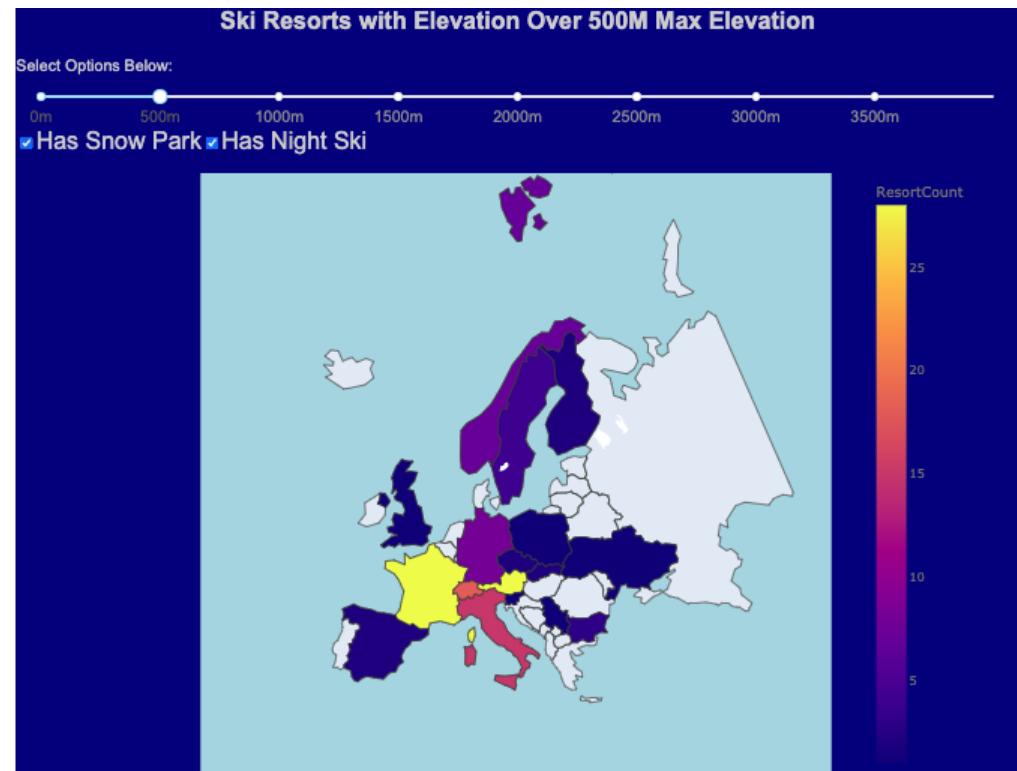
 NEW MESSAGE
April 3, 2023

From: **Leonard Lift** (Ski Trip Concierge)
Subject: Ski Resort Map Styling

Hey there,
Your HTML looked ok!
Let's modify the color and text on the Ski Resorts by Country map that we worked on.
Thanks again!

 [Reply](#)  [Forward](#)

Results Preview



SOLUTION: APP STYLING

 NEW MESSAGE
April 3, 2023

From: **Leonard Lift** (Ski Trip Concierge)
Subject: Ski Resort Map Styling

Hey there,
Your HTML looked ok!
Let's modify the color and text on the Ski Resorts by Country map that we worked on.
Thanks again!

 section05_solutions.ipynb  Reply  Forward

Solution Code

```
app.layout = html.Div([
    html.H2(id="title", style={"text-align": "center"}),
    html.P("Select Options Below:"),  

    dcc.Slider(
        id="Elevation Slider",
        min=0,
        max=4000,
        step=500,
        value=500,
        marks={
            i:{'label': f'{i}m', 'style': {"fontSize": 16}}
                for i in range(0, 4000, 500)}
    ),
    dcc.Checklist(
        id="Feature Checklist",
        options=["Has Snow Park", "Has Night Ski"],
        value=["Has Snow Park", "Has Night Ski"],
        style={"fontSize": 24}
    ),
    html.Br(),
    dcc.Graph(id="graph"),
], style={
    "backgroundColor": "darkblue",
    "color": "lightgrey",
    "font-family": "arial"
})
```



DASH BOOTSTRAP COMPONENTS

Dashboard Basics

HTML Layouts

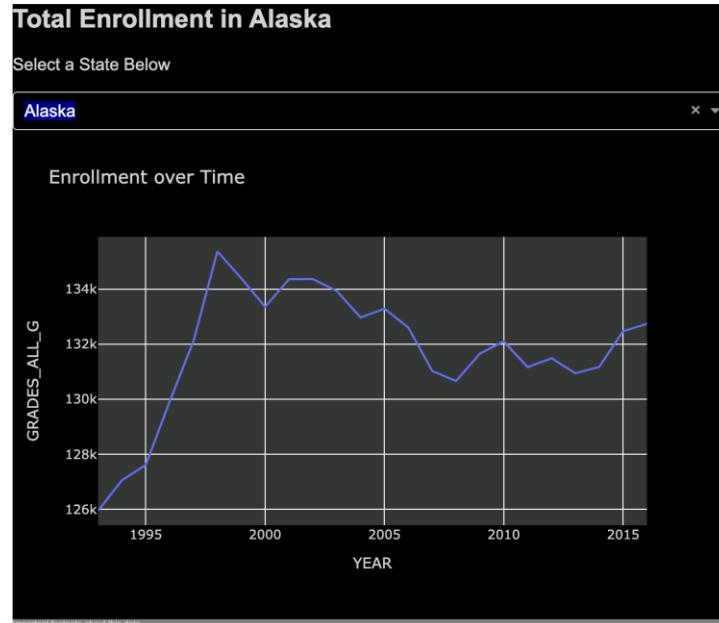
App Styling

Dash Bootstrap Components

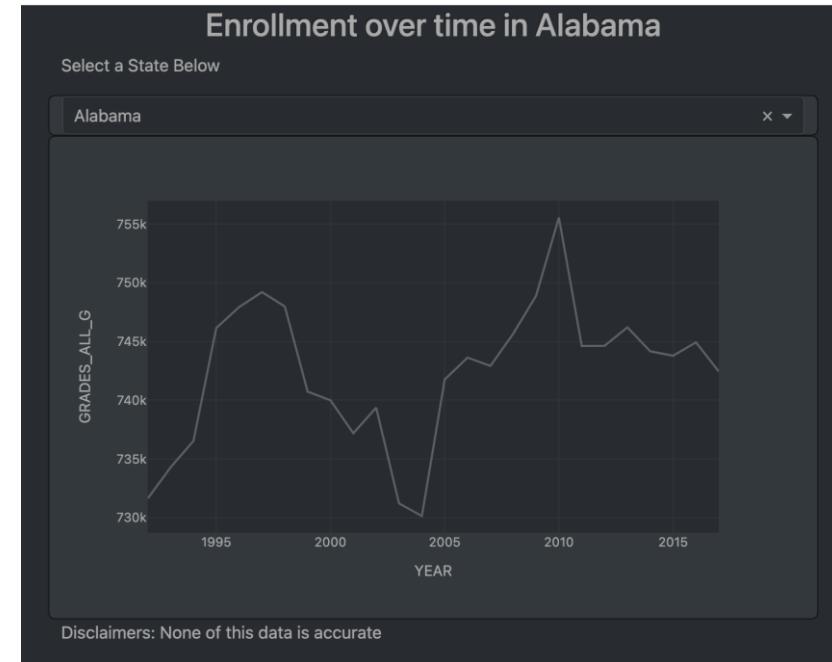
The **Dash Bootstrap Components** (DBC) library offers incredible options for designing polished applications with fewer lines of code

- This includes cohesive styles, built-in padding around components, and a grid-based framework

Individual component styling



Dash Bootstrap Components theme





DBC CHEATSHEET

Dashboard Basics

HTML Layouts

App Styling

Dash Bootstrap Components

These are the basic **Dash Bootstrap Components** you need to get started:

Component	Description
dbc.themes	Pre-built CSS style sheets that apply cohesive formatting to your application
dbc.Container()	The DBC equivalent of a Div that acts as a style wrapper for sections of the app layout
dbc.Card()	A specific type of container for components that adds padding & polish around them
dbc.Row()	Represents a horizontal row inside a dbc.Container (or html.Div)
dbc.Col()	Represents a vertical column inside a dbc.Row
dcc.Tabs()	Creates different tabs for users to navigate between



PRO TIP: Use Dash Bootstrap Components to quickly apply a theme to your dashboard, then tweak individual elements as needed with the methods we've already covered



DASH BOOTSTRAP THEMES

Dashboard Basics

HTML Layouts

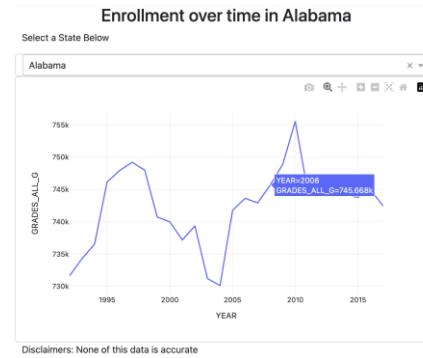
App Styling

Dash Bootstrap Components

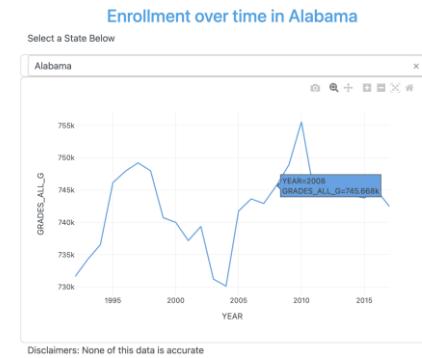
There are 26 **themes** available in the Dash Bootstrap Components library

- Dash(__name__, external_stylesheets=[dbc.themes.THEME_NAME])

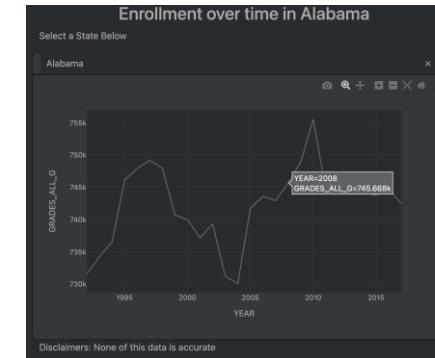
Bootstrap



Cerulean



Slate



Quartz



The **DBC Theme Explorer** (linked below) has an app for previewing the different themes available – odds are you will find one that matches your desired aesthetic!



DASH BOOTSTRAP THEMES

Dashboard Basics

HTML Layouts

App Styling

Dash Bootstrap Components

There are 26 **themes** available in the Dash Bootstrap Components library

- `Dash(__name__, external_stylesheets=[dbc.themes.THEME_NAME])`

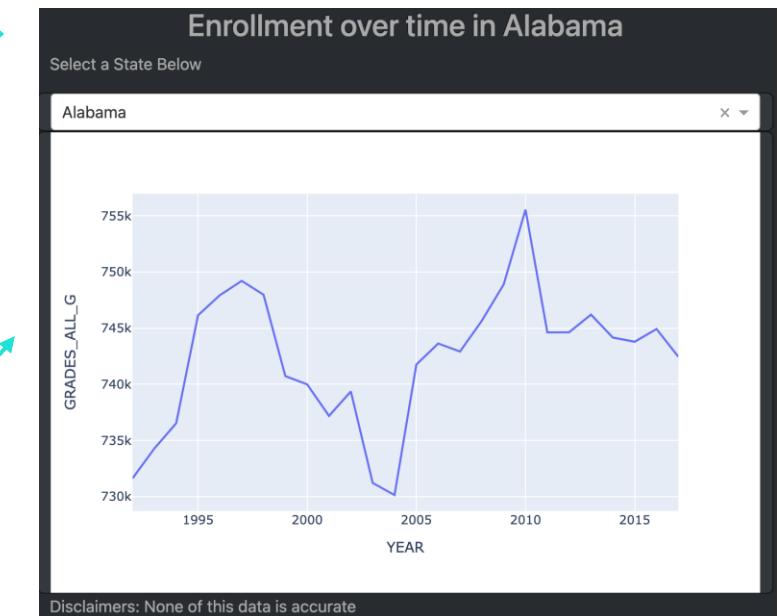
EXAMPLE

Applying the “slate” theme

```
app = JupyterDash(__name__, external_stylesheets=[dbc.themes.SLATE])
```

Simply specify the theme name here!

Note that the DCC components & Plotly figures don't adopt the style (for now!)





APPLYING THEMES TO FIGURES

Dashboard Basics

HTML Layouts

App Styling

Dash Bootstrap Components

You can **apply themes to figures** by using the `dash_bootstrap_templates` library

- `load_figure_template("THEME_NAME")`

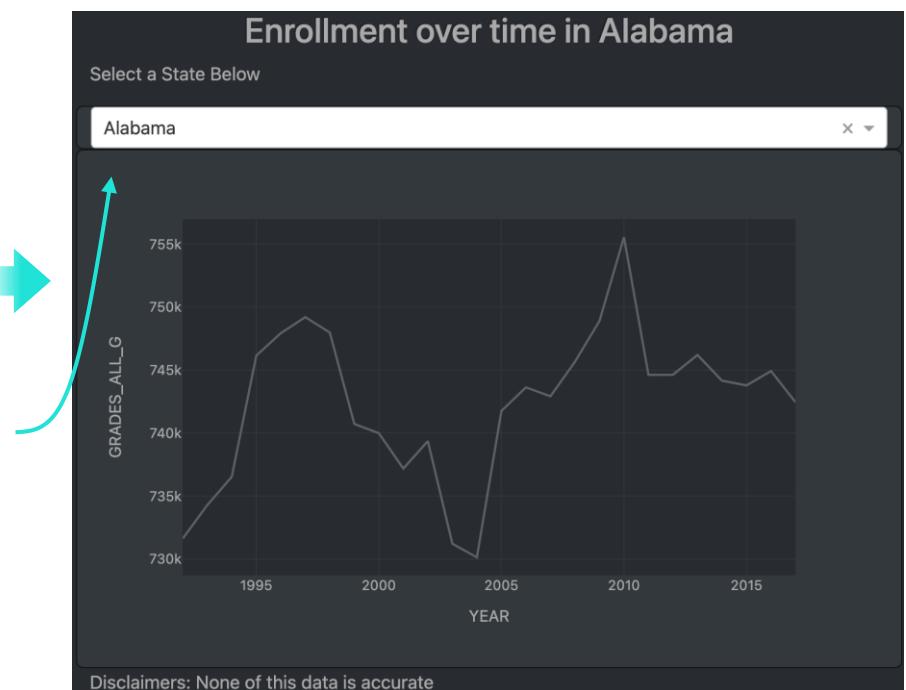
1) Install the library

```
from os import sys  
  
!pip install --prefix {sys.prefix} dash_bootstrap_templates
```

2) Specify the desired theme

```
from dash_bootstrap_templates import load_figure_template  
  
app = JupyterDash(__name__, external_stylesheets=[dbc.themes.SLATE])  
  
load_figure_template("SLATE")
```

Now we just need to deal with
this pesky dropdown menu!





APPLYING THEMES TO DCC COMPONENTS

Dashboard Basics

HTML Layouts

App Styling

Dash Bootstrap Components

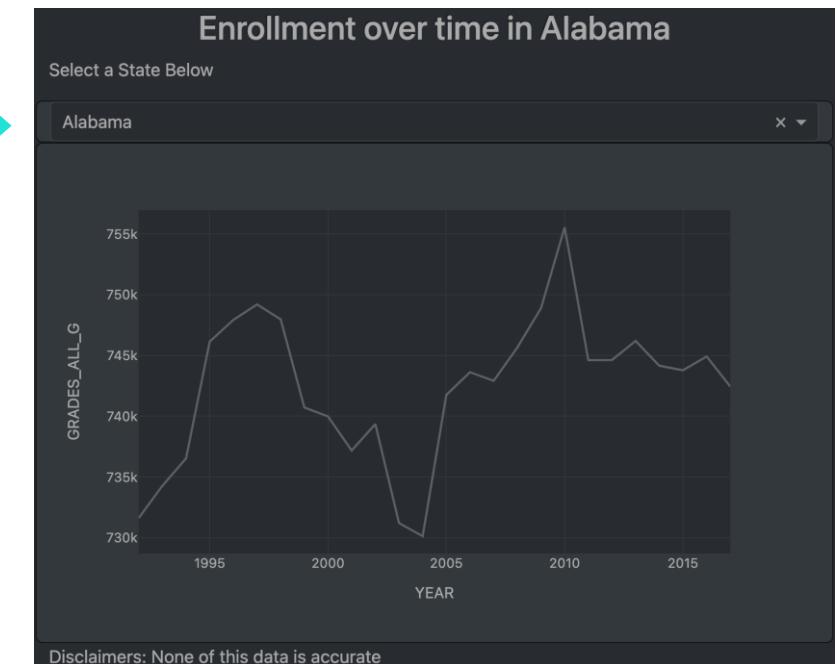
You can **apply themes to DCC components** by using a special link (see code below)

- You also need to specify className="dbc" in your dcc component

```
dbc_css = "https://cdn.jsdelivr.net/gh/AnnMarieW/dash-bootstrap-templates/dbc.min.css"  
  
app = JupyterDash(__name__, external_stylesheets=[dbc.themes.SLATE, dbc_css])  
  
load_figure_template("SLATE")  
  
app.layout = dbc.Container(  
    children=[  
        dbc.Row(  
  
            html.H2(  
                id="Header Text",  
                style={  
                    "textAlign": "center",  
                }),  
            html.P("Select a State Below", id='instructions'),  
            dbc.Row(  
                dbc.Card(  
                    dcc.Dropdown(  
                        options=[ "Alabama", "Alaska", "Arkansas"],  
                        value="Alabama",  
                        id="State Dropdown",  
                        className="dbc"  
                    ),  
                ),  
                dbc.Row(  
                    dbc.Card(dcc.Graph(id="Revenue Line")),  
                ),  
                html.P("Disclaimers: None of this data is accurate")  
            )  
        )  
    ]  
)
```

Imports external CSS
that applies to specified
dcc components

Applies theme to the component



You can **apply your own CSS code** with the same steps; Learning CSS is generally well beyond the scope of analyst roles, but it's worth being aware of if you have the web developer skills (or want to learn them!)



GRID BASED LAYOUTS

Dashboard Basics

HTML Layouts

App Styling

Dash Bootstrap Components

The DBC components for rows & columns let you create **grid-based layouts**

- The height of each row is determined by the height of its content
- You can specify the width of each column or let them distribute evenly by default

```
app.layout = dbc.Container([
    dbc.Row(
        dcc.Markdown(
            ...
            ## A Row without columns spans the whole app!
            ...
        ),
    ),
    dbc.Row(
        [
            dbc.Col("Width equal if not specified"),
            dbc.Col("Because total width is 12"),
            dbc.Col("3 Cols each have width 4"),
        ],
    ),
    dbc.Row(
        [
            dbc.Col("Width is 6", width=6),
            dbc.Col("Width is 3", width=3),
            dbc.Col("Width is 3", width=3),
        ]
    )
])
```



A Row without columns spans the whole app!

Width equal if not specified	Because total width is 12	3 Cols each have width 4
Width is 6	Width is 3	Width is 3



GRID BASED LAYOUTS

Dashboard Basics

HTML Layouts

App Styling

Dash Bootstrap Components

The DBC components for rows & columns let you create **grid-based layouts**

- The height of each row is determined by the height of its content
- You can specify the width of each column or let them distribute evenly by default

```
app.layout = dbc.Container([
    dbc.Row(
        dcc.Markdown(
            '''
            ## A Row without columns spans the whole app!
            ''',
        ),
    ),
    dbc.Row(
        [
            dbc.Col(dbc.Card("Width equal if not specified")),
            dbc.Col(dbc.Card("Because total width is 12")),
            dbc.Col(dbc.Card("3 Cols each have width 4")),
        ],
    ),
    dbc.Row(
        [
            dbc.Col(dbc.Card("Width is 6"), width=6),
            dbc.Col(dbc.Card("Width is 3"), width=3),
            dbc.Col(dbc.Card("Width is 3"), width=3),
        ]
    )
])
```



A Row without columns spans the whole app!

Width equal if not specified Because total width is 12 3 Cols each have width 4
Width is 6 Width is 3 Width is 3



PRO TIP: Even though it's not necessary, placing objects inside cards helps gives a better visual indication of the "grid" layout



GRID BASED LAYOUTS

Dashboard Basics

HTML Layouts

App Styling

Dash Bootstrap Components

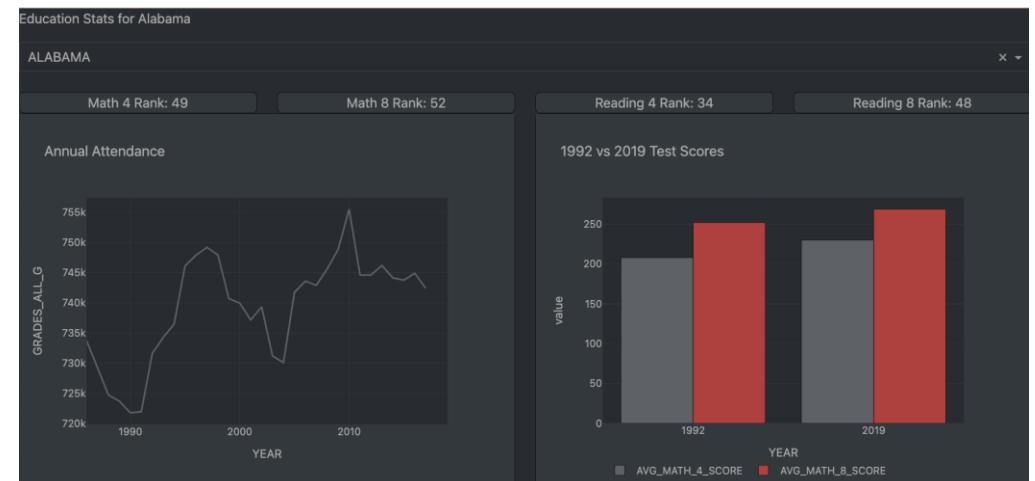
The DBC components for rows & columns let you create **grid-based layouts**

- The height of each row is determined by the height of its content
- You can specify the width of each column or let them distribute evenly by default

EXAMPLE

Adding KPI cards and another chart to our dashboard

```
app.layout = html.Div([
    dcc.Markdown(id="Markdown Title"),
    dbc.Row([
        dbc Dropdown(
            options=[ "ALABAMA", "ALASKA", "ARIZONA" ],
            value="ALABAMA",
            className="dbc",
            id="State Dropdown"
        ),
        html.Br(),
        dbc.Row([
            dbc.Col(dbc.Card(id="KPI 1"), style={"textAlign": "center"}),
            dbc.Col(dbc.Card(id="KPI 2"), style={"textAlign": "center"}),
            dbc.Col(dbc.Card(id="KPI 3"), style={"textAlign": "center"}),
            dbc.Col(dbc.Card(id="KPI 4"), style={"textAlign": "center"}),
        ]),
        dbc.Row([
            dbc.Col(dbc.Graph(id="Performance Over Time"))),
            dbc.Col(dbc.Graph(id="Funding Over Time")))
        ])
])
```





MULTIPLE TABS

Dashboard Basics

HTML Layouts

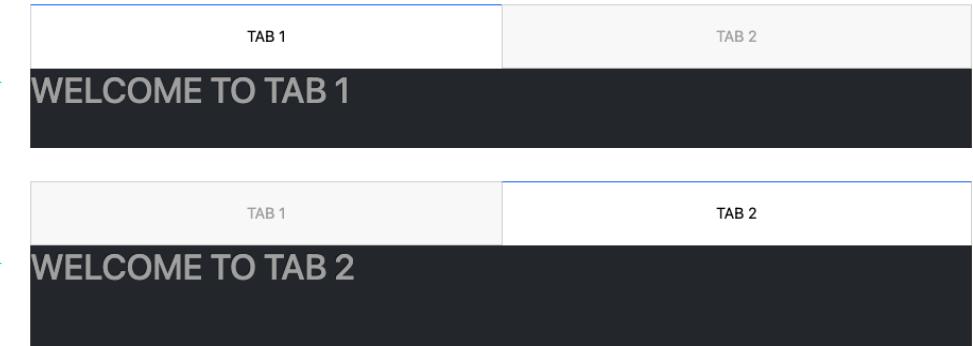
App Styling

Dash Bootstrap Components

You can create dashboards with **multiple tabs** with dcc.Tabs() and dcc.Tab()

- Simply specify any number of dcc.Tab() components underneath parent dcc.Tabs()

```
app.layout = html.Div(
    [
        dcc.Tabs(
            id="tabs",
            children=[
                dcc.Tab(
                    label="TAB 1",
                    value="tab1",
                    children = [html.H1("WELCOME TO TAB 1")]
                ),
                dcc.Tab(
                    label="TAB 2",
                    value="tab2",
                    children=[html.H1("WELCOME TO TAB 2")]
                )
            ]
        )
    ]
)
```



Note that the components in each tab are specified as a list in the "children" argument



MULTIPLE TABS

Dashboard Basics

HTML Layouts

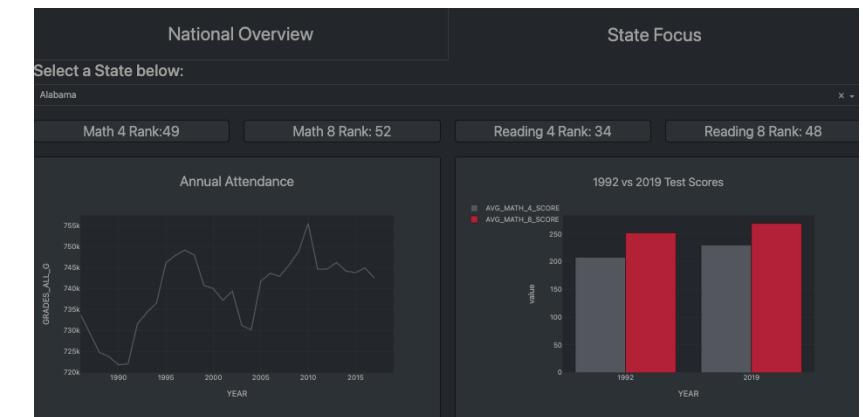
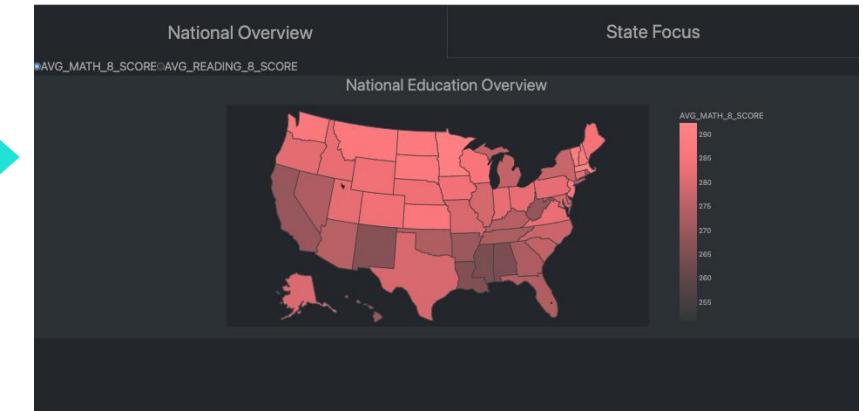
App Styling

Dash Bootstrap Components

EXAMPLE

Adding a new tab our dashboard

```
app.layout = html.Div([
    dcc.Tabs(
        id="tabs",
        value="tab-1",
        className="dbc",
        children=[
            dcc.Tab(
                label="National Overview",
                value="tab-1",
                className="dbc",
                children=[
                    dcc.RadioItems(),
                    dbc.Card(
                        dcc.Graph(id="state_stat_map"),
                    ),
                ],
            ),
            dcc.Tab(
                label="State Focus",
                value="tab-2",
                className="dbc",
                children=[
                    dbc.Markdown(id="Markdown Title"),
                    dbc.Row(dcc Dropdown(id="State Dropdown")),
                    html.Br(),
                    dbc.Row([
                        dbc.Col(dbc.Card(id="KPI 1"), style={"text-align": "center"}),
                        dbc.Col(dbc.Card(id="KPI 2"), style={"text-align": "center"}),
                        dbc.Col(dbc.Card(id="KPI 3"), style={"text-align": "center"}),
                        dbc.Col(dbc.Card(id="KPI 4"), style={"text-align": "center"}),
                    ]),
                    dbc.Row([
                        dbc.Col(dbc.Card(dcc.Graph(id="Performance Over Time"))),
                        dbc.Col(dbc.Card(dcc.Graph(id="Funding Over Time"))),
                    ]),
                ],
            ),
        ],
    ),
])
```



ASSIGNMENT: DASH BOOTSTRAP COMPONENTS

 NEW MESSAGE
April 05, 2023

From: **Leonard Lift** (Ski Trip Concierge)
Subject: Updated Layout

Hey there,

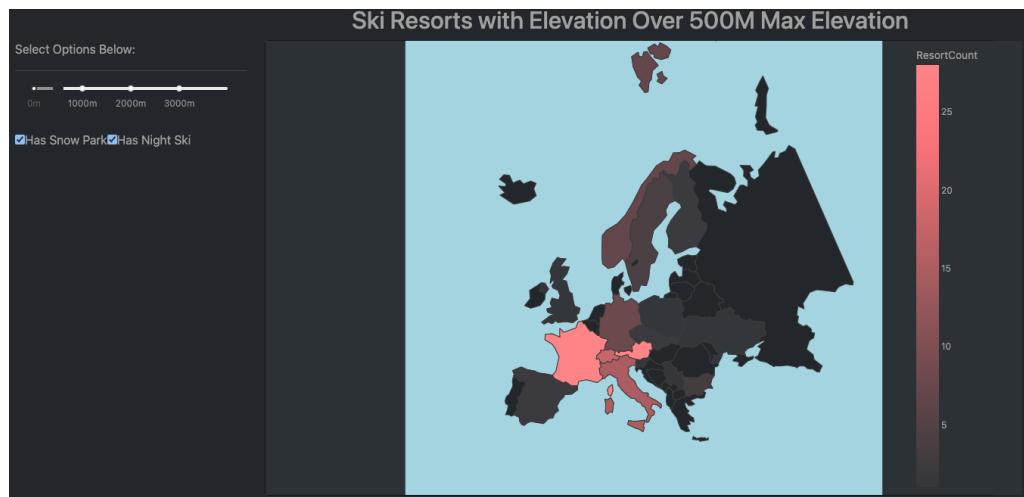
Can we modify the layout of the map application? I'd like for our interactive elements to be in a bar on the left side of our screen, with the map to the right.

Additionally, apply a dbc theme of your choice to the application... it's likely better than what you created earlier ;)

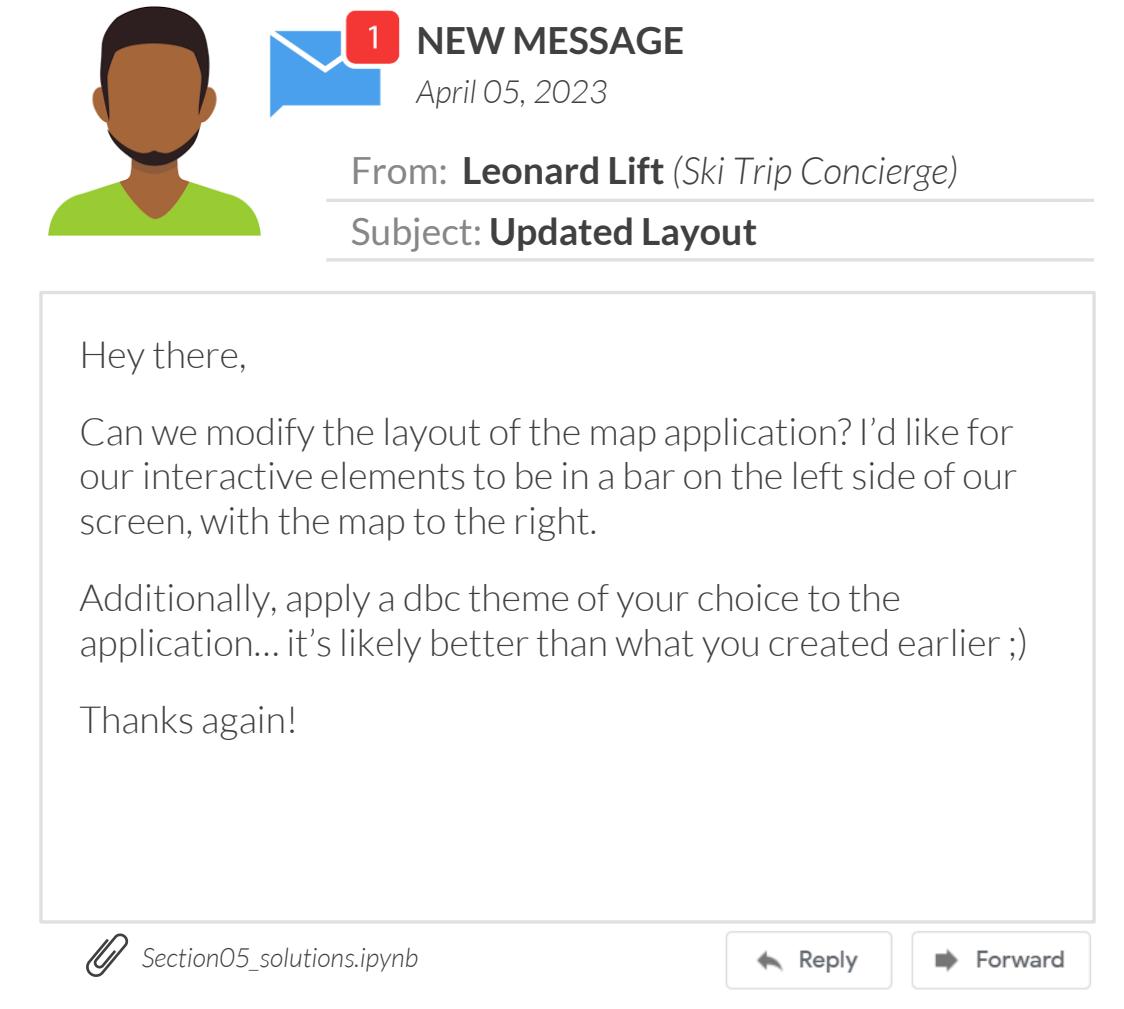
Thanks again!

 Reply  Forward

Results Preview



SOLUTION: DASH BOOTSTRAP COMPONENTS



A screenshot of an email application interface. On the left is a profile picture of a man with a beard. Next to it is a blue envelope icon with a red notification bubble containing the number '1'. To the right of the icon is the text 'NEW MESSAGE'. Below that is the date 'April 05, 2023'. The email body starts with 'From: Leonard Lift (Ski Trip Concierge)' and 'Subject: Updated Layout'. The message content is as follows:

Hey there,

Can we modify the layout of the map application? I'd like for our interactive elements to be in a bar on the left side of our screen, with the map to the right.

Additionally, apply a dbc theme of your choice to the application... it's likely better than what you created earlier ;)

Thanks again!

At the bottom are three buttons: a reply button with a left arrow, a forward button with a right arrow, and a file attachment icon with the text 'Section05_solutions.ipynb'.

Solution Code

```
app.layout = dbc.Container([
    dbc.Row([
        dbc.Col(width=3),
        dbc.Col(
            html.H2("HI", id="title", style={"text-align": "center"})
        )
    ]),
    dbc.Row([
        dbc.Col([
            html.P("Select Options Below:"),  

            html.Hr(),  

            dcc.Slider(  

                id="Elevation Slider",  

                min=0,  

                max=4000,  

                step=500,  

                value=500,  

                marks={i:{label: f'{i}m'} for i in range(0, 4000, 1000)},  

                className="dbc"
            ),  

            html.Br(),  

            dcc.Checklist(  

                id="Feature Checklist",  

                options=["Has Snow Park", "Has Night Ski"],  

                value=["Has Snow Park", "Has Night Ski"],
            )
        ], width=3),
        dbc.Col(dbc.Card(dcc.Graph(id="graph")), width=9)
    ])
])
```

KEY TAKEAWAYS



Dashboards are groups of visuals that help understand data at a glance

- *Adding filters & interactivity lets users explore the data themselves to see what insights emerge*



You can create **dashboard layouts** with HTML, markdown, and DBC

- *Dash Bootstrap Components (DBC) let you easily create grid-based layouts with multiple tabs*
- *The focus of the layout should be to add cohesion to its visuals and interactive elements*

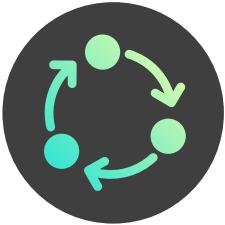


Themes let you easily apply pre-defined styles to your dashboards

- *You can still apply custom styles to individual components if needed*

ADVANCED TOPICS

ADVANCED TOPICS



In this section we'll cover **advanced topics** like chained & conditional callback functions, cross-filtering, debug mode, data table outputs, and app deployment options

TOPICS WE'LL COVER:

Data Tables

Advanced Callbacks

App Deployment

GOALS FOR THIS SECTION:

- Embed data tables that users can sort, filter, and export into Dash applications
- Write advanced callback function structures that take user interactivity to the next level
- Learn to deploy an application to an online server that stakeholders can access



DATA TABLES

You can embed **data tables** into your dashboards with the dash_table module

- dash_table.DataTable(columns, data)

Data Tables

Advanced
Callbacks

App Deployment

education.head()						
	STATE	YEAR	ENROLL	TOTAL_REVENUE	FEDERAL_REVENUE	STATE_REVENUE
0	ALABAMA	1992	NaN	2678885.0	304177.0	1659028.0
1	ALASKA	1992	NaN	1049591.0	106780.0	720711.0
2	ARIZONA	1992	NaN	3258079.0	297888.0	1369815.0
3	ARKANSAS	1992	NaN	1711959.0	178571.0	958785.0
4	CALIFORNIA	1992	NaN	26260025.0	2072470.0	16546514.0

```
from dash import dash_table

app.layout = html.Div(
    dash_table.DataTable(
        columns=[{"name": i, "id": i} for i in education.columns],
        data=education.to_dict("records"),
    )
)
```

This creates a table with the data from the "education" DataFrame with the column names as headers

STATE	YEAR	ENROLL	TOTAL_REVENUE	FEDERAL_REVENUE	STATE_REVENUE
ALABAMA	1992		2678885	304177	1659028
ALASKA	1992		1049591	106780	720711
ARIZONA	1992		3258079	297888	1369815
ARKANSAS	1992		1711959	178571	958785
CALIFORNIA	1992		26260025	2072470	16546514



DATA TABLES

You can use additional arguments to let users **sort**, **filter**, and **export** the table

- `dash_table.DataTable(columns, data, filter_action, sort_action, export_format)`

Data Tables

Advanced
Callbacks

App Deployment

The “native” options for sorting and filtering work quite well

You can also export to “xlsx”

```
from dash import dash_table

app.layout = html.Div(
    dash_table.DataTable(
        columns=[{"name": i, "id": i} for i in education.columns],
        data=education.to_dict("records"),
        filter_action="native",
        sort_action="native",
        export_format="csv"
    )
)
```

This was sorted by TOTAL_REVENUE with
the STATE filtered to “CALIFORNIA”



The **default style for tables isn’t the best**, but
they can be styled like any other HTML object
(DBC has a table implementation with better
aesthetics, but less functionality)

Export

STATE	YEAR	ENROLL	TOTAL_REVENUE	FEDERAL_REVENUE	STATE_REVENUE
CALIFORNIA	2016	6217031	89217262	7709079	50904567
CALIFORNIA	2015	6226523	78248042	7556365	42360470
CALIFORNIA	2008	6258421	74626928	7227456	43187637
CALIFORNIA	2009	6234155	73958896	9745250	40084244
CALIFORNIA	2007	6288686	72516936	7200298	42333637

ASSIGNMENT: DATA TABLES

 NEW MESSAGE
April 11, 2023

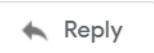
From: Leonard Lift (Ski Trip Concierge)
Subject: Table Output

Hey there,

Can you create a simple app that allows users to select country from a dropdown, uses our elevation slider, and returns a table of the resorts in that country with a highest point greater than the elevation specified?

Make sure the table can be sorted, filtered, and exported – some of our clients want to browse and analyze our data themselves. If you're up for it, try styling it!

Thanks!

Results Preview

Ski Resorts in Andorra with peaks above 1500M

Select Options Below:

Andorra

0m 500m 1000m 1500m 2000m 2500m 3000m 3500m

Export

Resort	Country	HighestPoint	LowestPoint	DayPassPriceAdult	BeginnerSlope
Soldeu-Pas de la Casa/Grau Roig/El Tarter/Canillo/Encamp (Grandvalira)	Andorra	2640	1710	47	100
Pal-Arinsal-La Massana-Vallnord	Andorra	1550	1230	37	31
Grandvalira – Pas de la Casa/Grau Roig/Soldeu/El Tarter/Canillo/Encamp	Andorra	2640	1710	47	100
El Tarter – Pas de la Casa/Grau Roig/Soldeu/Canillo/Encamp (Grandvalira)	Andorra	2640	1710	47	100
Arcalís-Ordino (Vallnord)	Andorra	2625	1940	37	13

SOLUTION: DATA TABLES



NEW MESSAGE

April 11, 2023

From: **Leonard Lift** (Ski Trip Concierge)
Subject: Table Output

Hey there,

Can you create a simple app that allows users to select country from a dropdown, uses our elevation slider, and returns a table of the resorts in that country with a highest point greater than the elevation specified?

Make sure the table can be sorted, filtered, and exported – some of our clients want to browse and analyze our data themselves. If you're up for it, try styling it!

Thanks!

Reply

Forward

Section06_solutions.ipynb

Solution Code

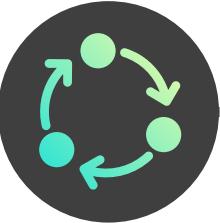
```
def elevation_table(elevation, country):
    if not elevation and country:
        raise PreventUpdate

    title = f"Ski Resorts in {country} with peaks above {elevation}M"

    df = ski_resorts.query("HighestPoint > @elevation and Country == @country")

    table = dash_table.DataTable(
        columns=[{"name": i, "id": i} for i in df.columns],
        data=df.to_dict("records"),
        filter_action="native",
        sort_action="native",
        export_format="xlsx",
        style_header={
            'backgroundColor': 'rgb(30, 30, 30)',
            'color': 'lightgrey',
            'font-family': "Arial"
        },
        style_data={
            'backgroundColor': 'rgb(50, 50, 50)',
            'color': 'grey',
            'font-family': "Arial"
        }
    )

    return title, table
```



ADVANCED CALLBACK FUNCTIONS

Data Tables

Advanced
Callbacks

App Deployment

Conditional Callbacks

Return different components to the front end based on some conditional logic

Chained Callbacks

Modify the options of an interactive element based on the option selected in another

Cross-Filtering Callbacks

Filter figures in the app based on the data selected (or hovered over) in another figure

Manual Callbacks

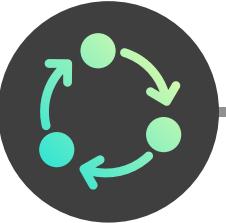
Prevent app updates until the user initiates the callback process, or “applies changes”

Periodic Callbacks

Updates the app by initiating the callback process at fixed time intervals



Dash is extremely powerful and flexible. These concepts are worth being aware of, but good dashboards are often quite simple, so you may never use most of these in practice



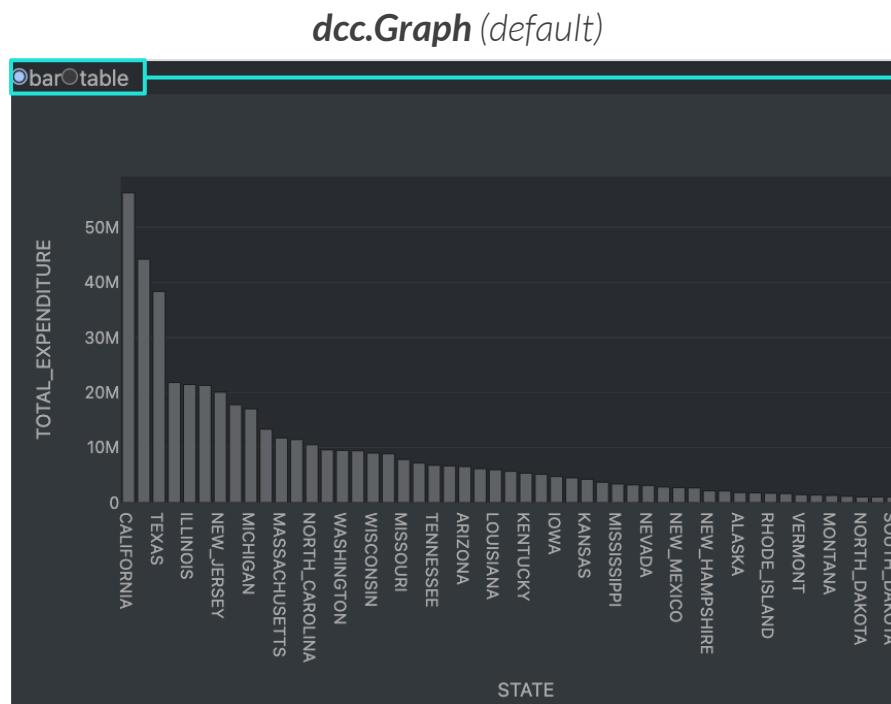
CONDITIONAL CALLBACKS

Data Tables

Advanced
Callbacks

App Deployment

Conditional callbacks use logical tests to return different types of components to the front end of your application



dash_table.DataTable

STATE	TOTAL_EXPENDITURE
CALIFORNIA	56247851.32
NEW YORK	44201162.8
TEXAS	38347089.88
PENNSYLVANIA	21813791.52
ILLINOIS	21444064.84
FLORIDA	21287605.24
NEW JERSEY	20051592.24
OHIO	17775446.24
MICHIGAN	17026245.84
GEORGIA	13332004.36
MASSACHUSETTS	11740076.32
VIRGINIA	11456358.48
NORTH CAROLINA	10512102.72
MARYLAND	9574154.72
WASHINGTON	9481863.84
INDIANA	9406665.08



CONDITIONAL CALLBACKS

Data Tables

Advanced
Callbacks

App Deployment

```
app.layout = html.Div([
    dcc.RadioItems(
        id="OutputPicker",
        options=["bar", "table"],
        value="bar"
    ),
    html.Div(id="Output Div")
])

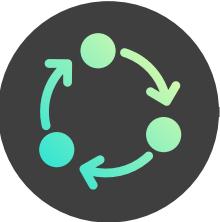
@app.callback(Output("Output Div", "children"), Input("OutputPicker", "value"))
def output_generator(output_style):
    if output_style == "bar":
        output = dcc.Graph(figure=px.bar(df, x="STATE", y="TOTAL_EXPENDITURE"))
    else:
        output = dash_table.DataTable(
            columns=[{"name": i, "id": i} for i in df.columns],
            data=df.to_dict("records"))

    return output
```

This gives the user two options: "bar" or table

This empty Div will house a component output by the "conditional" callback function

If the user selects "bar", the callback returns a dcc.Graph() component with a bar chart
Otherwise, if the user selects "table", the callback returns a DataTable object



CHAINED CALLBACKS

Data Tables

Advanced
Callbacks

App Deployment

Chained callbacks use the output of a callback function as the input of another

- This is typically used to modify the options of an interactive element based on the option selected in another (like *dependent dropdown lists*)

"California" selected (default)

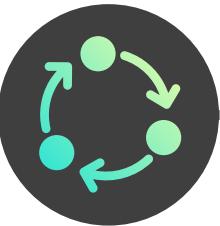
California	x ▾
Los Angeles	x ▲
Los Angeles	
San Diego	
San Francisco	

The second dropdown has cities in California as options

"Oregon" selected

Oregon	x ▾
Select...	▲
Bend	
Eugene	
Portland	

The second dropdown has cities in Oregon as options



CHAINED CALLBACKS

Data Tables

Advanced
Callbacks

App Deployment

Chained callbacks use the output of a callback function as the input of another

- This is typically used to modify the options of an interactive element based on the option selected in another (like dependent dropdown lists)

```
states_cities = {
    "California": ["Los Angeles", "San Diego", "San Francisco"],
    "Oregon": ["Bend", "Eugene", "Portland"],
    "Washington": ["Olympia", "Spokane", "Seattle"],
}

app.layout= html.Div([
    dcc.Dropdown(
        id="state-dropdown",
        options=[ "California", "Oregon", "Washington"],
        value="California",
        className="dbc"
    ),
    dcc.Dropdown(id="city-dropdown", value="Los Angeles", className="dbc"),
    dbc.Card(id="text-output")
])

@app.callback(
    Output("city-dropdown", "options"),
    Input("state-dropdown", "value"))
def set_metrics_options(selected_state):
    return states_cities[selected_state]

@app.callback(
    Output("text-output", "children"),
    Input("city-dropdown", "value"))
def plot_bar(city):
    if not city:
        raise PreventUpdate
    return f"You have selected {city}!"
```

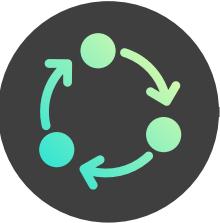
This dictionary sets the dependencies, with the keys being the options for the first dropdown, and the values are their corresponding options for the second dropdown

This is the first dropdown with the dictionary keys

This is the second dropdown with no options specified (yet!)

The first callback takes the value from the first dropdown as the input, and uses it as the key to return its values from the "states_cities" dictionary as options for the second dropdown

The second callback takes the value from the second dropdown and returns it to the dbc.Card component (you can use it to filter charts instead!)



PRO TIP: DEBUG MODE

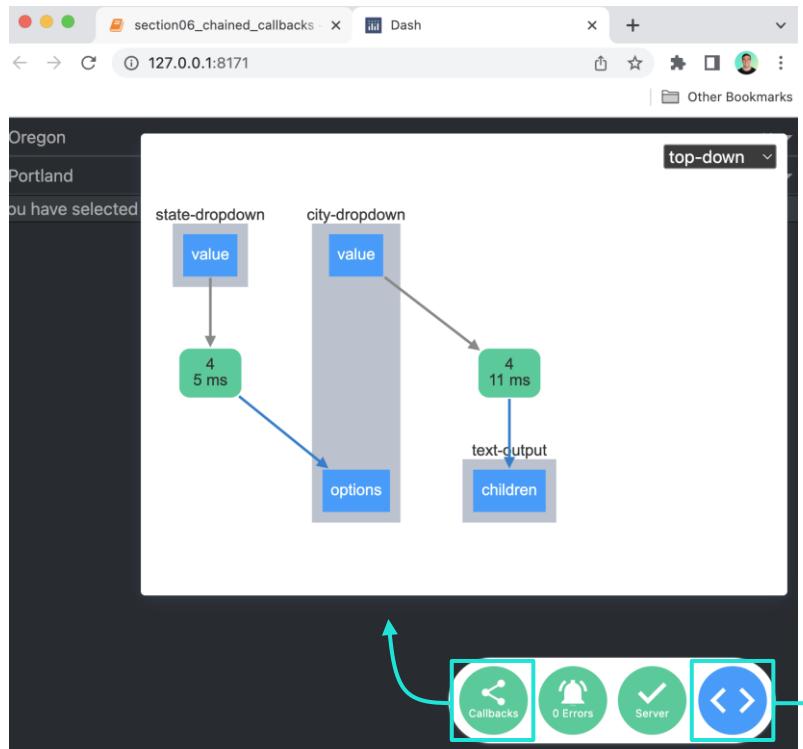
Data Tables

Advanced
Callbacks

App Deployment

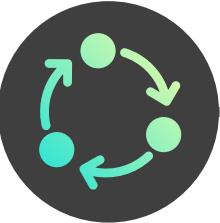
You can turn on **debug mode** when running an app to look at the structure of your callbacks, diagnose errors, and identify components causing poor performance

- `app.run_server(debug_mode=True)`



This **callback diagram** shows your app's components, their properties, and their callback relationships (and how long the callbacks take to run!)

This expands the **debug menu** shown here



PRO TIP: DEBUG MODE

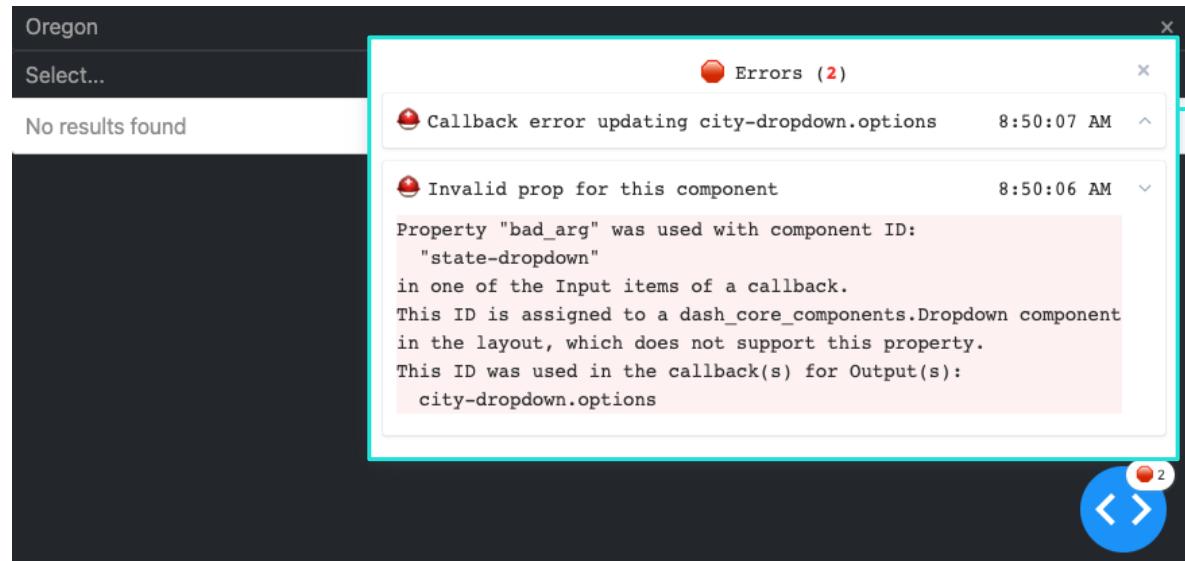
Data Tables

Advanced
Callbacks

App Deployment

You can turn on **debug mode** when running an app to look at the structure of your callbacks, diagnose errors, and identify components causing poor performance

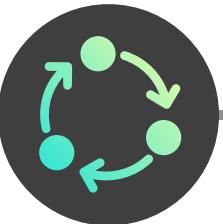
- `app.run_server(debug_mode=True)`



The error messages in debug mode are generated when interacting with the app, letting you pinpoint the cause of errors



PRO TIP: Use debug mode when building the app, and turn it off before deployment



CROSS-FILTERING

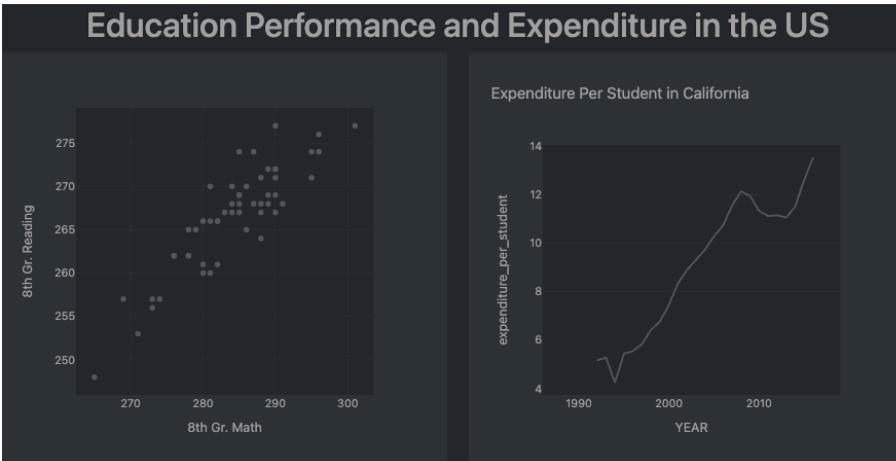
Cross-filtering uses chart selections as inputs to callbacks that filter other charts

Data Tables

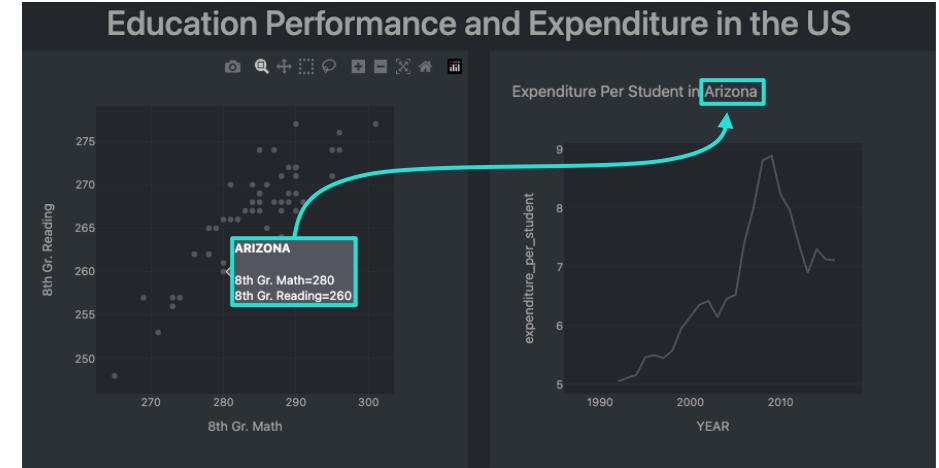
Advanced
Callbacks

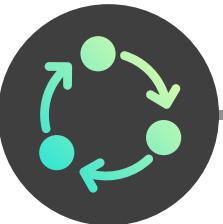
App Deployment

Load state (default)



Hover state





CROSS-FILTERING

Data Tables

Advanced
Callbacks

App Deployment

```
app.layout = html.Div([
    dbc.Row(
        html.H1("Education Performance and Expenditure in the US",
               style={"text-align": "center"})
    ),
    dbc.Row([
        dbc.Col(
            dcc.Graph(
                id="cross-filter-scatter",
                figure=px.scatter(
                    education.query("YEAR == 2013"),
                    x="8th Gr. Math",
                    y="8th Gr. Reading",
                    hover_name="STATE",
                    custom_data=[ "STATE" ]
                ),
                hoverData={'points': [{ 'customdata': [ 'CALIFORNIA' ] }]}
            )
        ),
        dbc.Col(dcc.Graph(id="x-line"))
    ])
])
@app.callback(
    Output("x-line", "figure"),
    Input("cross-filter-scatter", "hoverData"))
def update_line(hoverData):
    state_name = hoverData["points"][0]["customdata"][0]
    df=education.query("STATE == @state_name")

    fig = px.line(
        df,
        x="YEAR",
        y="expenditure_per_student",
        title=f"Expenditure Per Student in {state_name.title()}"
    ).update_xaxes(showgrid=False)

    return fig
```

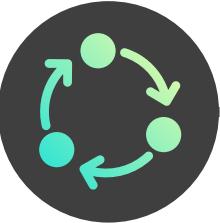
The **custom_data** argument lets you specify which column(s) to grab values from when the user hovers over a datapoint

The **hoverData** argument in `dcc.Graph()` lets you specify a starting value to pass through before the user hovers over a datapoint

The callback function input is the `hoverData` from the scatterplot

This grabs the “STATE” value from the `hoverData` dictionary passed through the callback and uses it to filter the DataFrame

This plots a line chart with the “cross-filtered” DataFrame!



PRO TIP: MANUAL CALLBACKS

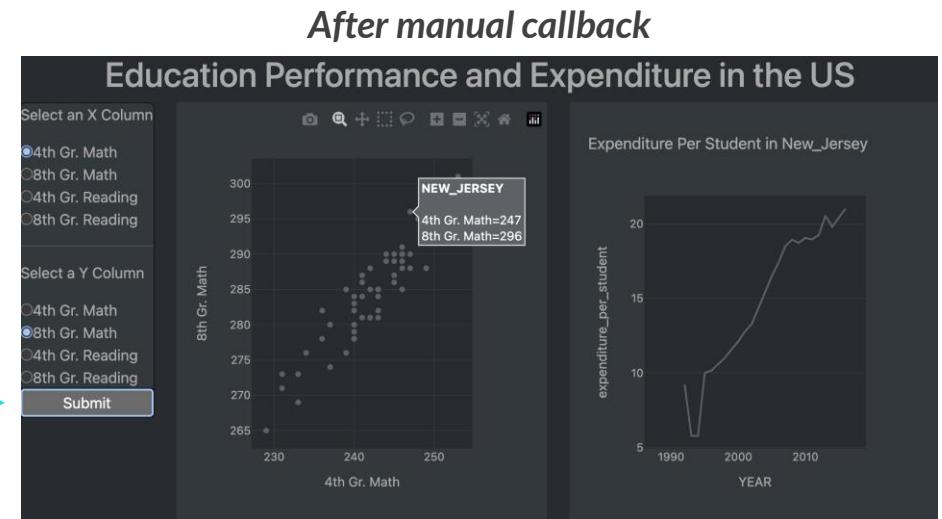
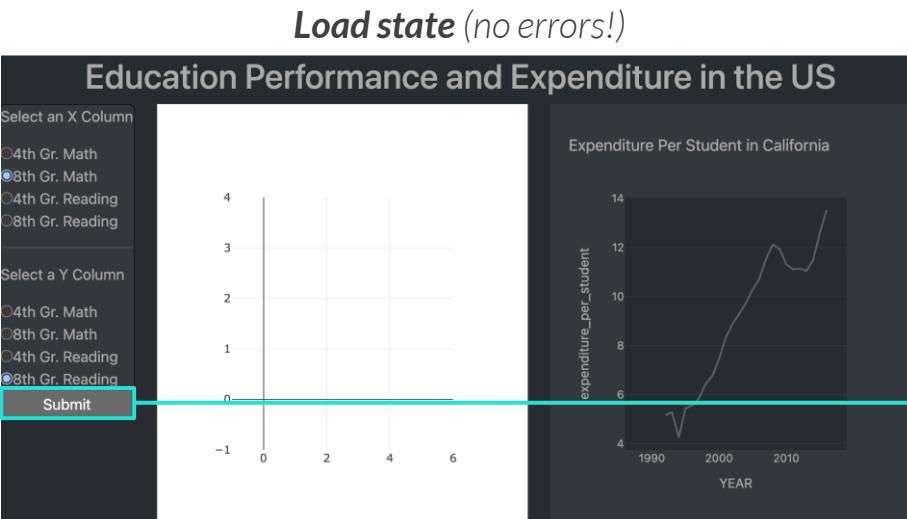
Data Tables

Advanced
Callbacks

App Deployment

You can add a button component to your app that **run callbacks manually**, allowing users to make multiple selections before applying any updates

- This helps if your application has long processing times (*common in ML models*)



The first chart relies on inputs from the radio buttons on the left, but the callback function won't fire until the user clicks "Submit" (the second chart is displaying default values, and is unrelated to the radio buttons on the left)

The first chart now displays values based on the user selections, and is also filtering the second chart by the selected data point



PRO TIP: MANUAL CALLBACKS

Data Tables

Advanced
Callbacks

App Deployment

```
app.layout = html.Div([
    dbc.Row(html.H1("Education Performance and Expenditure in the US", style={"text-align": "center"})),
    dbc.Row([
        dbc.Col([
            dbc.Card([
                dcc.Markdown("Select an X Column"),
                dcc.RadioItems(
                    id="score-radio",
                    options=["4th Gr. Math", "8th Gr. Math", "4th Gr. Reading", "8th Gr. Reading"],
                    value="8th Gr. Math"
                ),
                html.Hr(),
                dcc.Markdown("Select a Y Column"),
                dcc.RadioItems(
                    id="score-radio2",
                    options=["4th Gr. Math", "8th Gr. Math", "4th Gr. Reading", "8th Gr. Reading"],
                    value="8th Gr. Reading"
                ),
                html.Button("Submit", id="submit-button", n_clicks=0)])
            ], width=2),
            dbc.Col(dcc.Graph(id="cross-filter-scatter",
                               hoverData={'points': [{'customdata': ['CALIFORNIA']}]}), width=5),
            dbc.Col(dcc.Graph(id="x-line"), width=5)
        ])
    ])
]

@app.callback(
    Output("cross-filter-scatter", "figure"),
    Input("score-radio", "value"),
    Input("score-radio2", "value"),
    Input("submit-button", "n_clicks")
)
def score_scatter(x, y, n_clicks):
    if not n_clicks:
        raise PreventUpdate
```

This adds the "Submit" button and sets the "n_clicks" property equal to 0

The "n_clicks" property from the button gets passed as an input into the callback

If the button has not been clicked, then the app doesn't update (n_clicks=None)



PRO TIP: PERIODIC CALLBACKS

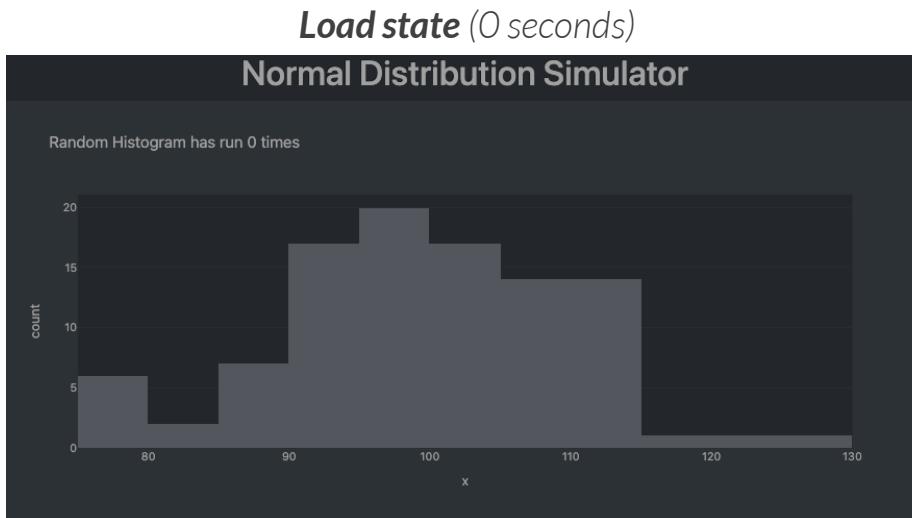
Data Tables

Advanced
Callbacks

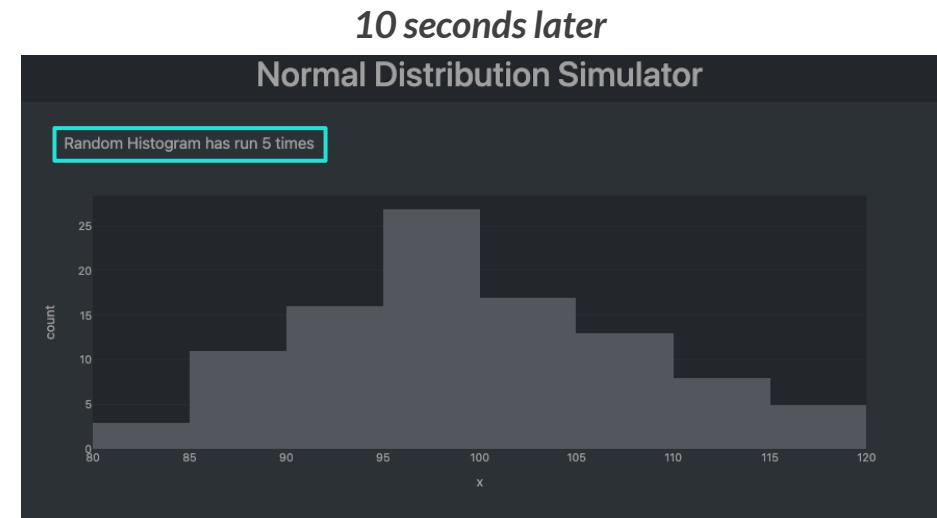
App Deployment

You can schedule **periodic callbacks** with the `dcc.Interval()` component

- This lets you update your app automatically without user input
- `dcc.Interval(interval, n_intervals)`



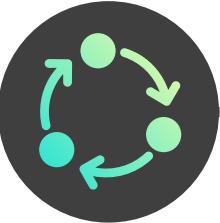
This app is set to "refresh" every 2 seconds



In 10 seconds, 5 callbacks have triggered every 2 seconds



This can allow for **real-time updates** if your application is connected to a database or API, so instead of firing a random number generator, new data can be queried and appended to your DataFrame via `pd.read_sql()`



PRO TIP: PERIODIC CALLBACKS

Data Tables

Advanced
Callbacks

App Deployment

You can schedule **periodic callbacks** with the dcc.Interval() component

- This lets you update your app automatically without user input
- dcc.Interval(interval, n_intervals)

```
from numpy.random import default_rng
rng=default_rng(2023)

app.layout = html.Div([
    dbc.Row(html.H1("Normal Distribution Simulator", style={"text-align": "center"})),
    dbc.Row(dbc.Col(dcc.Graph(id="random-data-scatter"))),
    dcc.Interval(id="refresh-data-interval", interval=2000, n_intervals=0) → This will trigger every 2,000 milliseconds (2 seconds)
])

@app.callback(
    Output("random-data-scatter", "figure"),
    Input("refresh-data-interval", "n_intervals")
)

def score_scatter(n_intervals):
    mean, stddev = 100, 10
    fig = px.histogram(
        x=rng.normal(mean, stddev, size=100),
        title=f"Random Histogram has run {n_intervals} times"
    )
    return fig → This creates a histogram with randomized normal data, and show how many times it has run
    (you don't need to use n_intervals in the function)
```

ASSIGNMENT: ADVANCED CALLBACKS

 **1 NEW MESSAGE**
April 20, 2023

From: Leonard Lift (Ski Trip Concierge)
Subject: Updated Table App

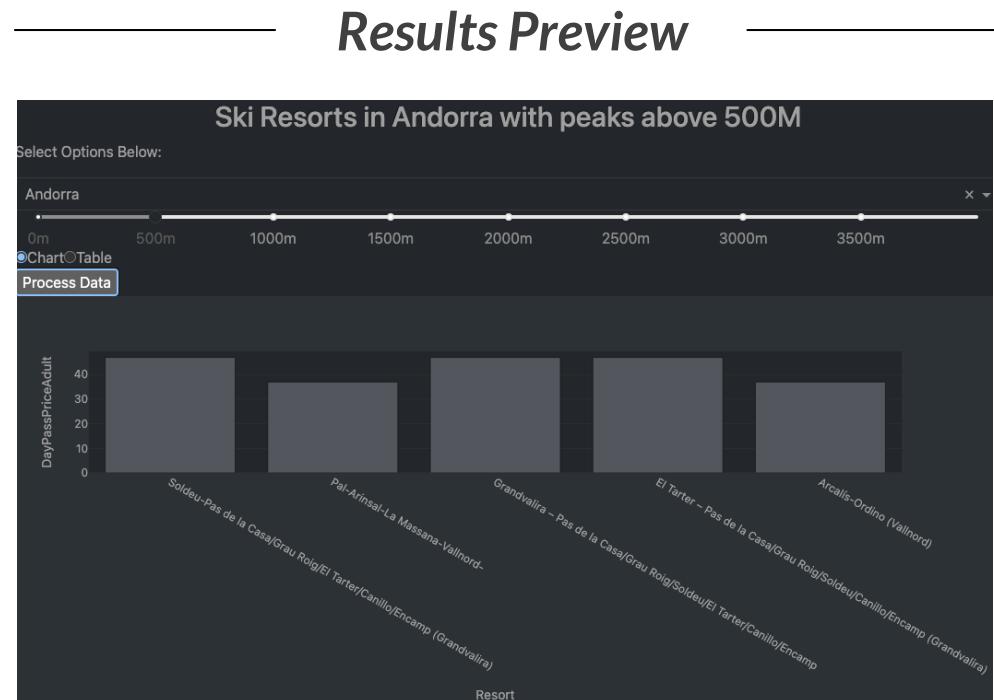
Hey there,

Can we update the table application we created earlier to include a few more features?

I'd like the user to be able to select whether a bar chart or a table is returned, and I don't want the app to run until the user clicks a button to confirm their choices.

Thanks!



SOLUTION: ADVANCED CALLBACKS

 NEW MESSAGE
April 20, 2023

From: **Leonard Lift** (Ski Trip Concierge)
Subject: Updated Table App

Hey there,

Can we update the table application we created earlier to include a few more features?

I'd like the user to be able to select whether a bar chart or a table is returned, and I don't want the app to run until the user clicks a button to confirm their choices.

Thanks!

 section06_solutions.ipynb  Reply  Forward

Solution Code

```
def elevation_table(country, elevation, output_option, n_clicks):
    if not n_clicks:
        raise PreventUpdate

    title = f"Ski Resorts in {n_clicks} with peaks above {elevation}M"
    df = ski_resorts.query("HighestPoint > @elevation and Country == @country")

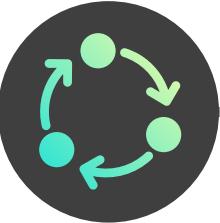
    if output_option == "Table":

        output = dash_table.DataTable(
            columns=[{"name": i, "id": i} for i in df.columns],
            data=df.to_dict("records"),
            filter_action="native",
            sort_action="native",
            export_format="xlsx",
            style_header={
                'backgroundColor': 'rgb(30, 30, 30)',
                'color': 'lightgrey',
                'font-family': "Arial"
            },
            style_data={
                'backgroundColor': 'rgb(50, 50, 50)',
                'color': 'grey',
                'font-family': "Arial"
            }
        )

    else:
        output = dcc.Graph(figure=px.bar(df, x="Resort", y="DayPassPriceAdult"))

    n_clicks=0

    return title, output, n_clicks
```



DEPLOYING YOUR APP

Data Tables

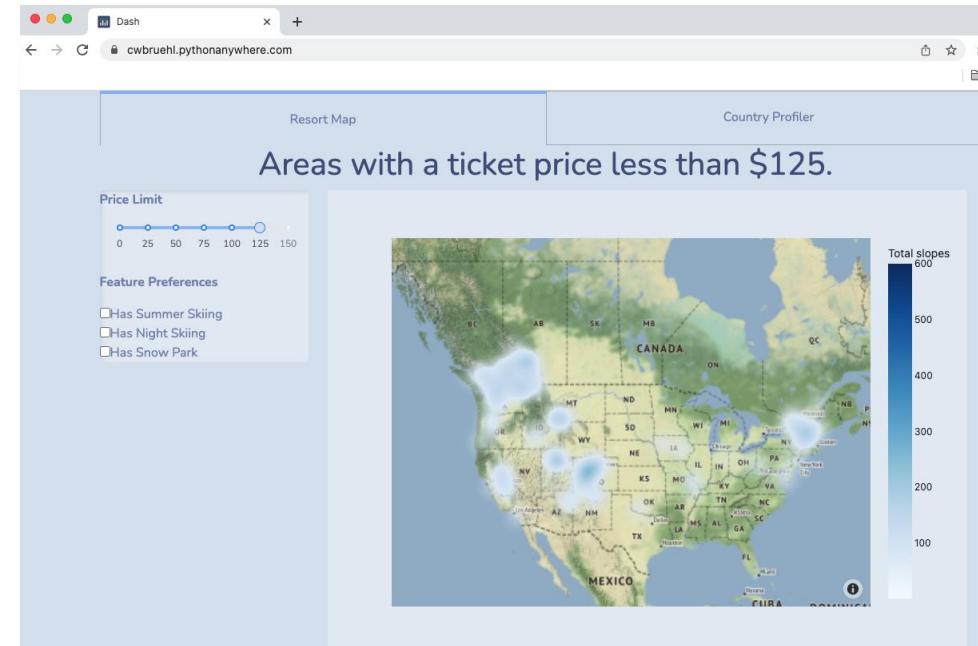
Advanced
Callbacks

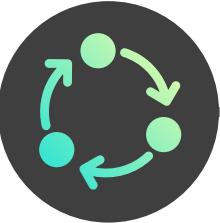
App Deployment

Deploying your app requires access to a server

- For professional projects, you can use cloud services like AWS and Azure, or Dash Enterprise
- For personal projects, you can use PythonAnywhere or Heroku

This is hosted on
PythonAnywhere





PYTHONANYWHERE

You can deploy your app on **PythonAnywhere** for free by following these steps:

Data Tables

Advanced
Callbacks

App Deployment

1) Go to [pythonanywhere.com/pricing](https://www.pythonanywhere.com/pricing) and click [Create a Beginner account](#)

2) Register, then **upload your app** and **data files**

The screenshot shows the PythonAnywhere dashboard for user [cwbreuhl](#). The dashboard includes sections for CPU Usage (0% used), File storage (16% full), and recent activity. A callout points to the 'Recent Files' section, which lists files like `/home/cwbreuhl/dash_app.py`, `/var/www/cwbreuhl_pythonanywhere_com_wsgi.py`, and `/home/cwbreuhl/app.py`. Below this section are buttons for '+ Open another file' and 'Browse files'. To the right, there's a 'Recent Notebooks' section (empty) and an 'All Web apps' section showing the URL `cwbreuhl.pythonanywhere.com`.

Dashboard Consoles Files Web Tasks Databases

Welcome, [cwbreuhl](#)

Upgrade Account

CPU Usage: 0% used – 0.00s of 2,000s. Resets in 21 hours, 32 minutes [More Info](#)

File storage: 16% full – 673.0 MB of your 4.0 GB quota [More Info](#)

Recent Consoles + 5 -

Bash console in virtualenv myvirt...
Bash console in virtualenv myvirt...
Bash console in virtualenv myvirt...
Bash console 26822931
Python3.10 console 26822926

[View all](#)

New console: \$ Bash >>> Python < More...

Recent Files + 6 -

/home/cwbreuhl/dash_app.py
/var/www/cwbreuhl_pythonanywhere_com_wsgi.py
/home/cwbreuhl/app.py

+ Open another file Browse files

Recent Notebooks + 5 -

You have no recent notebooks.

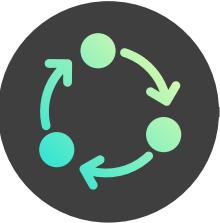
+ Add new (Python 3.10)
Browse all files

All Web apps

cwbreuhl.pythonanywhere.com

Open Web tab

Upload our app file (`file_name.py`) and any data used (like CSV files)



PYTHONANYWHERE

Data Tables

Advanced
Callbacks

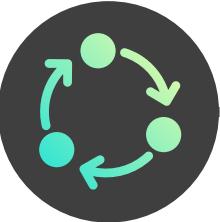
App Deployment

You can deploy your app on **PythonAnywhere** for free by following these steps:

3) Go to the “Web” tab and **add a new web app**

The screenshot shows the 'Add a new web app' wizard on the PythonAnywhere dashboard. The top navigation bar includes 'Dashboard', 'Consoles', 'Files', **Web**, 'Tasks', and 'Databases'. A message on the right says 'You have no web apps' with a note to click the 'Add a new web app' button. The main form has a step counter '1 of 5' and a title 'Your web app's domain name'. It asks 'Where do you want your web app to be?' with options: 'cwbruehl.pythonanywhere.com' (selected) and 'Your own domain:' with a field 'www.enter-your-domain-here.com'. Below this is a section 'Select a Python Web framework' with 'Manual configuration (including virtualenvs)' selected from a list including Django, web2py, Flask, Bottle, and Manual configuration. A note says 'I'll need to set up a -domain.com is hosted we will display the value'. At the bottom are 'Back' and 'Next >' buttons. A separate 'Manual Configuration' box provides details about editing a WSGI config file and creating a simple 'Hello World' app.

Click “Manual Configuration”
and select Python “3.10”



PYTHONANYWHERE

Data Tables

Advanced
Callbacks

App Deployment

You can deploy your app on **PythonAnywhere** for free by following these steps:

4) Your default app is **live!**

Configuration for [cwbruehl.pythonanywhere.com](#)

Reload:

Reload cwbruehl.pythonanywhere.com

Hello, World!

This is the default welcome page for a [PythonAnywhere](#) hosted web application.

Find out more about how to configure your own web application by visiting the [web app setup](#) page

5) Go to the “Consoles” tab and **start a new Bash Console**

pythonanywhere
by ANACONDA.

[Dashboard](#) **Consoles** [Files](#) [Web](#) [Tasks](#) [Databases](#)

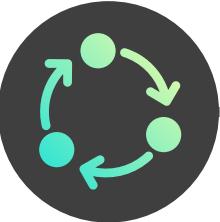
CPU Usage: 0% used – 0.00s of 2,000s. Resets in 23 hours, 41 minutes [More Info](#)

Start a new console:

Python: [3.10](#) / [3.9](#) / [3.8](#) / [3.7](#) / [3.6](#) IPython: [3.10](#) / [3.9](#) / [3.8](#) / [3.7](#) / [3.6](#) PyPy: [2](#) / [3](#)

Other: [Bash](#) | [MySQL](#)

Custom:



PYTHONANYWHERE

Data Tables

Advanced
Callbacks

App Deployment

You can deploy your app on **PythonAnywhere** for free by following these steps:

- 6) Type “mkvirtualenv myvirtualenv --python=/usr/bin/python3.10” to **create an environment**

```
18:35 ~ $ mkvirtualenv myvirtualenv --python=/usr/bin/python3.10
^[[created virtual environment CPython3.10.5.final.0-64 in 17314ms
creator CPython3Posix(dest=/home/cwbruehl/.virtualenvs/myvirtualenv, clear=False, no_vcs_ignore=False, global=False)
seeder FromAppData(download=False, pip=bundle, setuptools=bundle, wheel=bundle, via=copy, app_data_dir=/home/cwbruehl/.local/share/virtualenv)
added seed packages: Brotli==1.0.9, Flask==1.1.2, Flask_Compress==1.13, Jinja2==2.11.3, MarkupSafe==2.0.1, Werkzeug==2.0.3, attrs==22.2.0, certifi==2017.1
1.5, chardet==3.0.4, charset_normalizer==2.1.1, click==6.7, dash==2.7.0, dash_bootstrap_components==1.3.0, dash_bootstrap_templates==1.0.7, dash_core_componen
ts==2.0.0, dash_html_components==2.0.0, dash_renderer==0.11.1, dash_table==5.0.0, decorator==4.1.2, fastjsonschema==2.16.2, idna==3.4, ipython_genutils==0.2.0
, itsdangerous==2.0.1, jsonschema==4.16.0, jupyter_core==4.11.2, nbformat==5.7.0, numpy==1.24.1, pandas==1.5.2, pip==22.3.1, plotly==5.9.0, pyrsistent==0.19.3
, python_dateutil==2.8.2, pytz==2022.1, requests==2.28.1, setuptools==65.6.3, six==1.16.0, tenacity==8.1.0, traitlets==5.1.1, urllib3==1.26.13, wheel==0.38.4
activators BashActivator,CShellActivator,FishActivator,NushellActivator,PowerShellActivator,PythonActivator
(myvirtualenv) 18:36 ~ $
```

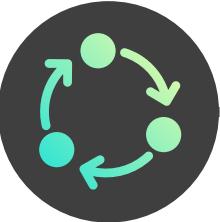
- 7) Go to the “Web” tab and **connect your app to your environment**

Virtualenv:

Use a virtualenv to get different versions of flask, django etc from our default system ones. [More info here](#). You need to **Reload your web app** to activate it; NB - will do nothing if the virtualenv does not exist.

/home/cwbruehl/.virtualenvs/myvirtualenv

Replace “cwbruehl” with your username



PYTHONANYWHERE

Data Tables

Advanced
Callbacks

App Deployment

You can deploy your app on **PythonAnywhere** for free by following these steps:

- 8) In the “Web” tab, **edit the WSGI configuration file** with the code below and click “Save”

Code:

What your site is running.

Source code: *Enter the path to your web app source code*

/home/cwbruehl/

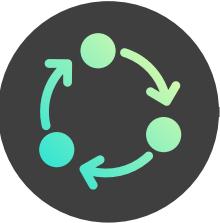
Go to directory

Working directory: /var/www/cwbruehl_pythonanywhere_com_wsgi.py

WSGI configuration file: /var/www/cwbruehl_pythonanywhere_com_wsgi.py

Python version: 3.10

```
1 import sys
2
3 # add your project directory to the sys.path
4 project_home = u'/home/cwbruehl/' → Your username
5 if project_home not in sys.path:
6     sys.path = [project_home] + sys.path
7
8 from project_app import app → The name of the module (.py file) storing your application
9 application = app.server
```



PYTHONANYWHERE

Data Tables

Advanced
Callbacks

App Deployment

You can deploy your app on **PythonAnywhere** for free by following these steps:

9) Make **tweaks to your code** to prepare it for deployment

```
from dash import Dash, dcc, html  
app = Dash(__name__, external_stylesheets=[dbc.themes.MORPH, dbc_css])
```

Make sure you're using **Dash** instead of Jupyter_Dash

```
return resort_name, elev_rank, price_rank, slope_rank, cannon_rank
```

Remove **app.run_server()** – the last lines of code should be the final callback function



Code tweaks can be done prior to uploading your code as well! There are good arguments for editing it both before and after upload, but either way will get you a running the app!

10) Specify the **file path** to your app in the “Source code”

Code:

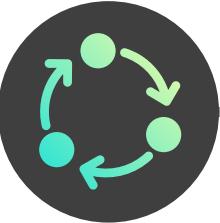
What your site is running.

Source code: `/home/cwbruehl/project_app.py`

Working directory: `/home/cwbruehl/`

WSGI configuration file: `/var/www/cwbruehl_pythonanywhere_com_wsgi.py`

Python version: 3.10



PYTHONANYWHERE

Data Tables

Advanced
Callbacks

App Deployment

11) Reload and **visit your app!**

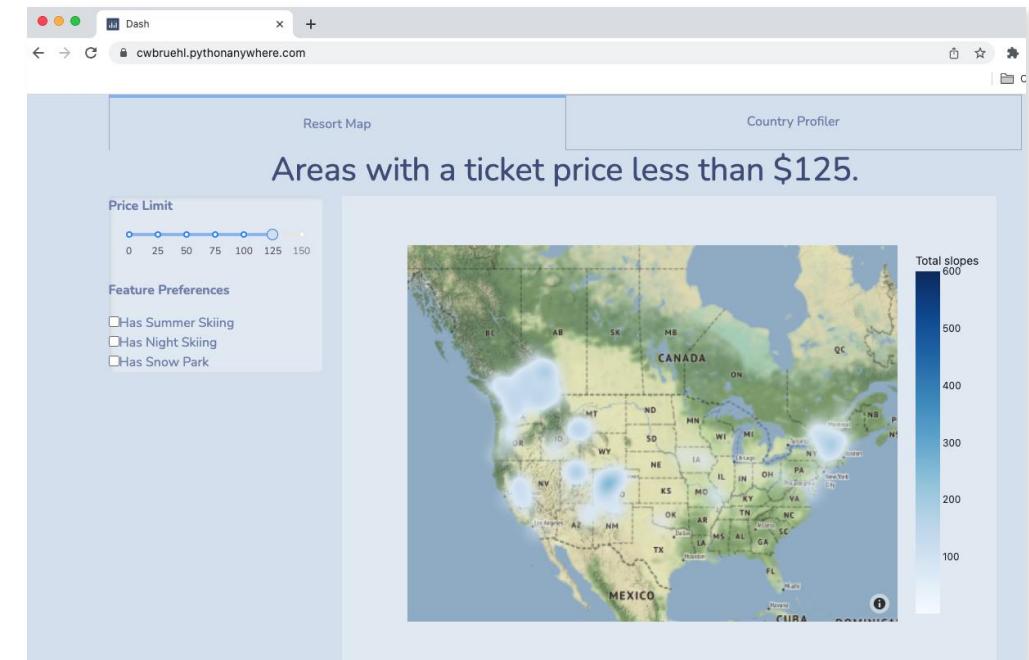
Configuration for cwbruehl.pythonanywhere.com

Reload:

[Reload cwbruehl.pythonanywhere.com](#)



Got stuck somewhere? Check out PythonAnywhere's help documentation – most of these steps are covered there! (they also have a great example of a Dash app deployment)



KEY TAKEAWAYS



You can embed **data tables** into your Dash applications

- *This lets users inspect & analyze the raw data by sorting, filtering, or exporting it*



Advanced callback functions take user interactivity to the next level

- *Conditional, chained, and cross-filter callbacks let users explore the data in a wide variety of ways*
- *Manual and periodic callbacks let users control when callbacks are fired*



Dash applications are meant to be **deployed**

- *If you're building an application for work, consult your IT department about company or cloud-based servers*
- *Python Anywhere is a solid free option for deploying your app (Heroku is another popular option)*

FINAL PROJECT

PROJECT DATA: WORLDWIDE RESORTS

```
resorts.head()
```

ID	Resort	Latitude	Longitude	Country	Continent	Price	Season	Highest point	Lowest point	
0	1	Hemsedal	60.928244	8.383487	Norway	Europe	46	November - May	1450	620
1	2	Geilosiden Geilo	60.534526	8.206372	Norway	Europe	44	November - April	1178	800
2	3	Golm	47.057810	9.828167	Austria	Europe	48	December - April	2110	650
3	4	Red Mountain Resort-Rossland	49.105520	-117.846280	Canada	North America	60	December - April	2075	1185
4	5	Hafjell	61.230369	10.529014	Norway	Europe	45	November - April	1030	195

5 rows × 25 columns

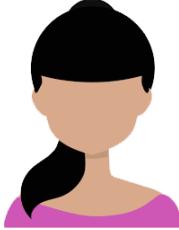


MAVELUXE

```
resorts.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 499 entries, 0 to 498
Data columns (total 25 columns):
 #   Column           Non-Null Count  Dtype  
--- 
 0   ID               499 non-null    int64  
 1   Resort            499 non-null    object  
 2   Latitude          499 non-null    float64 
 3   Longitude         499 non-null    float64 
 4   Country           499 non-null    object  
 5   Continent         499 non-null    object  
 6   Price             499 non-null    int64  
 7   Season            499 non-null    object  
 8   Highest point     499 non-null    int64  
 9   Lowest point      499 non-null    int64  
 10  Beginner slopes   499 non-null    int64  
 11  Intermediate slopes 499 non-null    int64  
 12  Difficult slopes  499 non-null    int64  
 13  Total slopes      499 non-null    int64  
 14  Longest run       499 non-null    int64  
 15  Snow cannons       499 non-null    int64  
 16  Surface lifts     499 non-null    int64  
 17  Chair lifts        499 non-null    int64  
 18  Gondola lifts      499 non-null    int64  
 19  Total lifts        499 non-null    int64  
 20  Lift capacity      499 non-null    int64  
 21  Child friendly     499 non-null    object  
 22  Snowparks          499 non-null    object  
 23  Nightskiing        499 non-null    object  
 24  Summer skiing      499 non-null    object  
dtypes: float64(2), int64(15), object(8)
memory usage: 97.6+ KB
```

ASSIGNMENT: FINAL PROJECT

  **NEW MESSAGE**
May 1, 2023

From: Deepthi Downhill (VP of Analytics)
Subject: Even MORE Ambitious Resort App

Hey, thanks for the great work on the two dashboards. However, I'm getting some feedback that having two separate dashboards is challenging to navigate. Can you make this a single app, with each view on its own tab? Try to improve the design a bit as well.

We also want to think EVEN BIGGER. The US and Canada were a great start, but we have access to data on ski resorts world-wide, and we should be able to leverage much of our existing code to include all of them.

Thanks!

 section07_final_project.ipynb Reply Forward

Key Objectives

1. Build a multi-tab dashboard with a grid-based layout
2. Add multiple chart types and interactive elements
3. Write standard callback functions to connect them
4. Include a chained callback function and (if you're daring) a cross-filtering callback function

