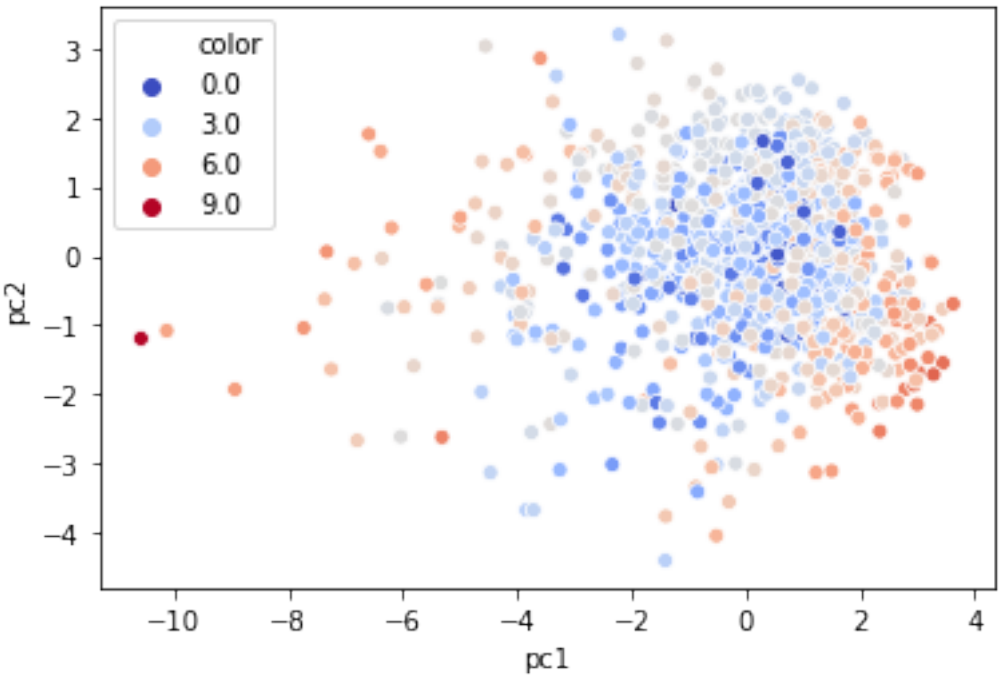
Notebook

October 22, 2019

0.1 Question 2d

Create a 2D scatterplot of the first two principal components of `mid1_grades_centered_scaled`. Use `colorize_midterm_data` to add a `color` column to `mid1_1st_2_pcs`. Your code will be very similar to the code from problems 2a and 2b.

```
In [39]: u_2, s_2, vt_2 = np.linalg.svd(mid1_grades_centered_scaled, full_matrices = False)
         mid1_centered_scaled_1st_2_pcs = pd.DataFrame(u_2 @ np.diag(s_2))[[0,1]]
         mid1_centered_scaled_1st_2_pcs = mid1_centered_scaled_1st_2_pcs.rename(columns={0:'pc1',1:'pc2
         sns.scatterplot(data = colorize_midterm_data(mid1_centered_scaled_1st_2_pcs), x = "pc1", y = "
```

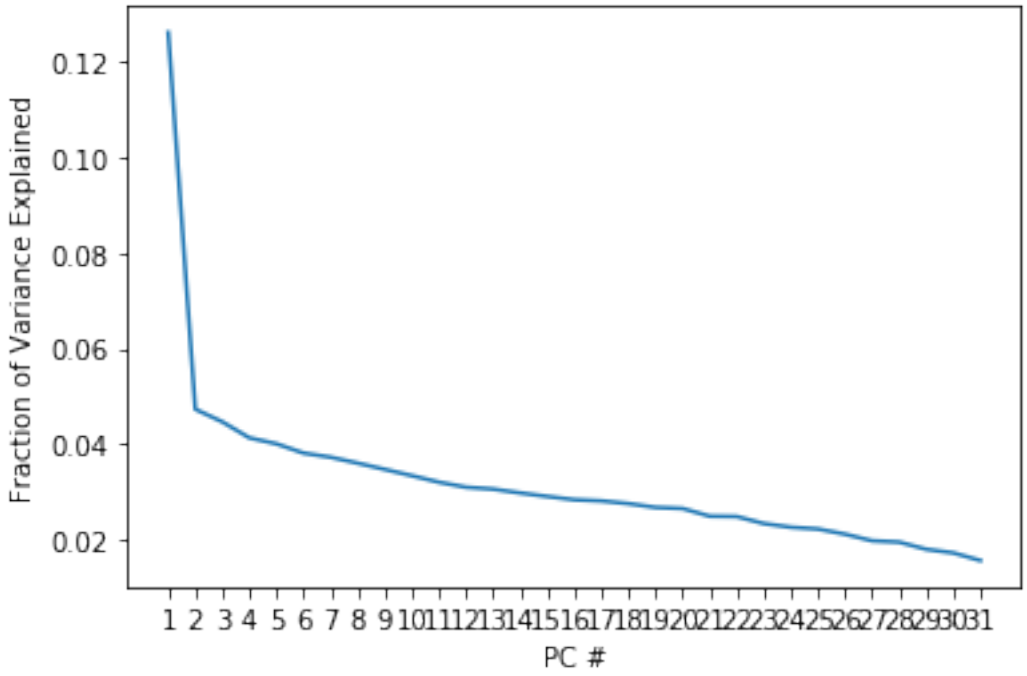


0.2 Question 2e

If you compute the fraction of the variance captured by this 2D scatter plot, you'll see it's only 17%, roughly 12% by the 1st PC, and roughly 5% by the 2nd PC. **In the cell below, create a scree plot showing the fraction of the variance explained by PC #i.**

Informally, we can say that our midterm scores matrix has a high rank. More formally, we can say that a rank 2 approximation only captures a small fraction of the variance, and thus the data are not particularly amenable to 2D PCA scatterplotting.

```
In [40]: plt.plot([i+1 for i in range(31)], s_2**2 / sum(s_2**2));
         plt.xticks([i+1 for i in range(31)], [i+1 for i in range(31)]);
         plt.xlabel('PC #');
         plt.ylabel('Fraction of Variance Explained');
```



Unfortunately, we have two problems:

1. There is a lot of overplotting, with only 27 distinct dots. This means that at least some states voted exactly alike in these elections.
2. We don't know which state is which, because the points are unlabeled.

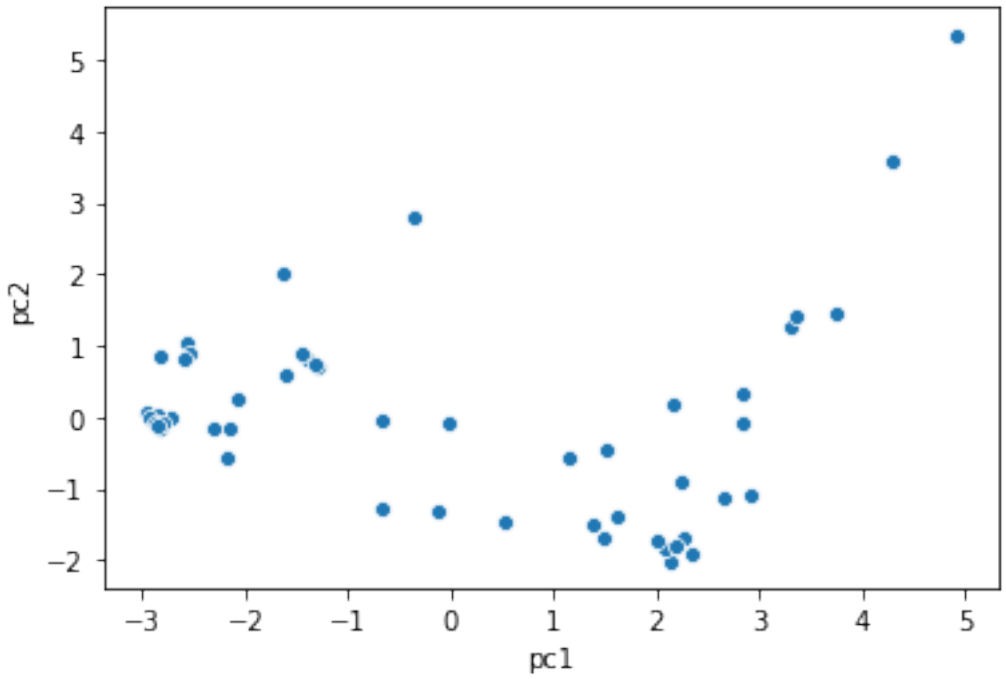
Let's start by addressing problem 1.

In the cell below, create a new dataframe `first_2_pcs_jittered` with a small amount of random noise added to each principal component. In this same cell, create a scatterplot.

The amount of noise you add should not significantly affect the appearance of the plot, it should simply serve to separate overlapping observations.

Hint: See the pairplot from the intro to question 2 for an example of how to introduce noise.

```
In [52]: first_2_pcs_jittered = first_2_pcs + np.random.normal(0, 0.1, size = (len(first_2_pcs), 2))
         sns.scatterplot(data = first_2_pcs_jittered, x = "pc1", y = "pc2");
```



0.3 Question 3g

To label our points, the best option is to use the `plotly` library that we used earlier in this homework. Plotly is an incredibly powerful plotting library that will automatically add axis labels, and will also provide controls so that you can zoom and pan around to look at the data.

One important skill as a user of modern tools is using existing documentation and examples to get the plot you want.

Using the example given on this page as a guide:, create a scatter plot of your **jittered data** from 3f with the following key properties:

1. Your plot should be created using `px.scatter`, and should use the `fig.update_traces` method to set the `textposition`.
2. Each point should be labeled by the name of the state, and the label should be above the point.

Hint: You can get a list of the state names with `list(df_1972_to_2016.index)`.

Hint: `gapminder` in the example linked is just the name of their dataframe. Your code shouldn't have anything to do with `gapminder` since we're plotting presidential election data, not life expectancies and gdp.

In [53]:
```
first_2_pcs_jittered['State'] = df_1972_to_2016.index

import plotly.express as px


fig = px.scatter(first_2_pcs_jittered, x="pc1", y="pc2", text='State')

fig.update_traces(textposition='top center')

fig.update_layout(
    height=800,
    title_text='Presidential Election Data per State, 1972-2016'
)

fig.show()
```

Give an example of a cluster of states that vote a similar way. Does the composition of this cluster surprise you? If you're not familiar with U.S. politics, it's fine to just say 'No, I'm not surprised because I don't know anything about U.S. politics.'.

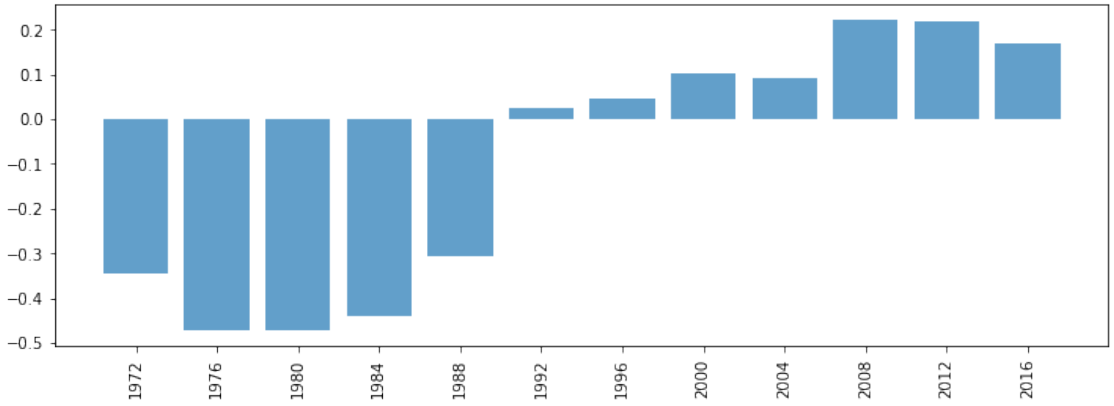
No, I'm not surprised because I don't know anything about U.S. politics. But it is surprising to see majority republican voting states together and the majority democratic voting states together

In the cell below, write down anything interesting that you observe by looking at this plot. You will get credit for this as long as you write something reasonable that you can take away from the plot.

But it is surprising to see majority republican voting states together and the majority democratic voting states together. Also, DC voted all Democratic and hence their pc_1 and pc_2 are the highest. Alaska on the other hand has a primarily republican voting and hence it's pc1 is negative. pc_1 seems to determine if state votes republican or democratic

In the cell below, plot the the 2nd row of V^T.
Hint: You are just copying and pasting code from the cell above and then changing one number.

```
In [55]: with plt.rc_context({"figure.figsize": (12, 4)}):
             plot_pc(list(df_1972_to_2016.columns), vt_3, 1);
```



0.4 Question 3i

Using your plots from question 3h as well as the original table, give a description of what it means to have a relatively large positive value for `pc1` (right side of the 2D scatter plot), and what it means to have a relatively large positive value for `pc2` (top side of the 2D scatter plot).

In other words, what is generally true about a state with relatively large positive value for `pc1`? For a large positive value for `pc2`?

Note: `pc2` is pretty hard to interpret, and the staff doesn't really have a concensus on what it means either. We'll be nice when grading.

Note: Principal components beyond the first are often hard to interpret (but not always, see question 1 earlier in this homework)

pc1: Large Positive Value means that the state votes Democratic mainly and negative values refer to the state voting republican mainly.

pc2: Large Positive Value if the state voted mostly democratic from 1972-1988, aka had a negative value in df_1972_2016. During the 1972-1988 years, the voting except for in 1976, was very uniform with most states opting for one party over the other. This could explain why states who voted Democratic in this period have a large pc_2 positive value. Whereas States who voted republican in this period and shifted to democratic later, example, Conneticut have a pc_2 negative value. This could be used to see how voting changed over the years for some states.

0.5 Question 3j

To get a better sense of whether our 2D scatterplot captures the whole story, create a scree plot for this data. On the y-axis plot the fraction of the total variance captured by the ith principal component. You should see that the first two principal components capture much more of the variance than we were able to capture when using the DS100 midterm 1 data. It is partially for this reason that the 2D scatter plot was so much more useful for this dataset.

Hint: Your code will be very similar to the scree plot from problem 1d. Be sure to label your axes appropriately!

```
In [57]: plt.plot([i+1 for i in range(12)], s_3**2 / sum(s_3**2));
         plt.xticks([i+1 for i in range(12)], [i+1 for i in range(12)]);
         plt.xlabel('PC #');
         plt.ylabel('Fraction of Variance Explained');
```