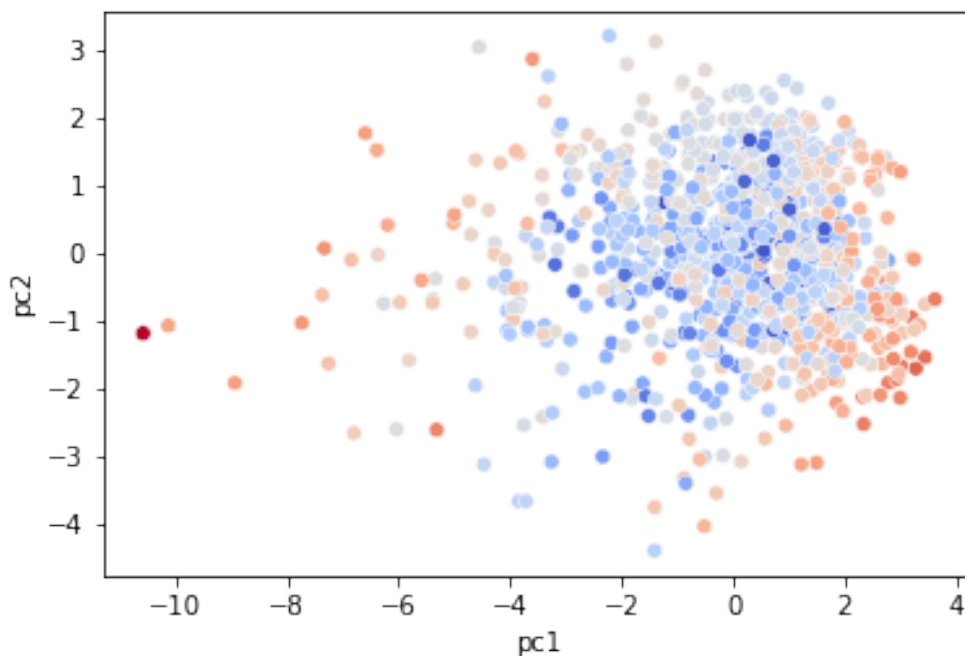


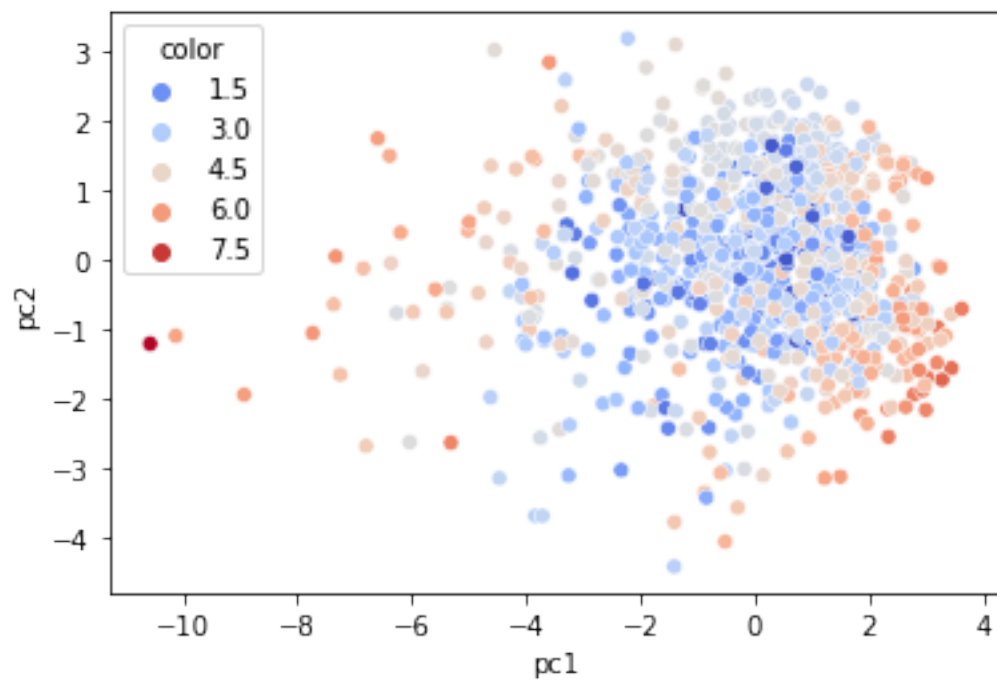
0.1 Question 2d

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. Your result should look like this



```
In [100]: u, s, vt=np.linalg.svd(mid1_grades_centered_scaled, full_matrices=False)
mid1_1st_2_pcs=pd.DataFrame(data=(u*s)[:,:0:2], columns=['pc1','pc2'])
sns.scatterplot(data=colorize_midterm_data(mid1_1st_2_pcs), x="pc1", y="pc2", hue="color", pa
```

```
Out[100]: <AxesSubplot:xlabel='pc1', ylabel='pc2'>
```

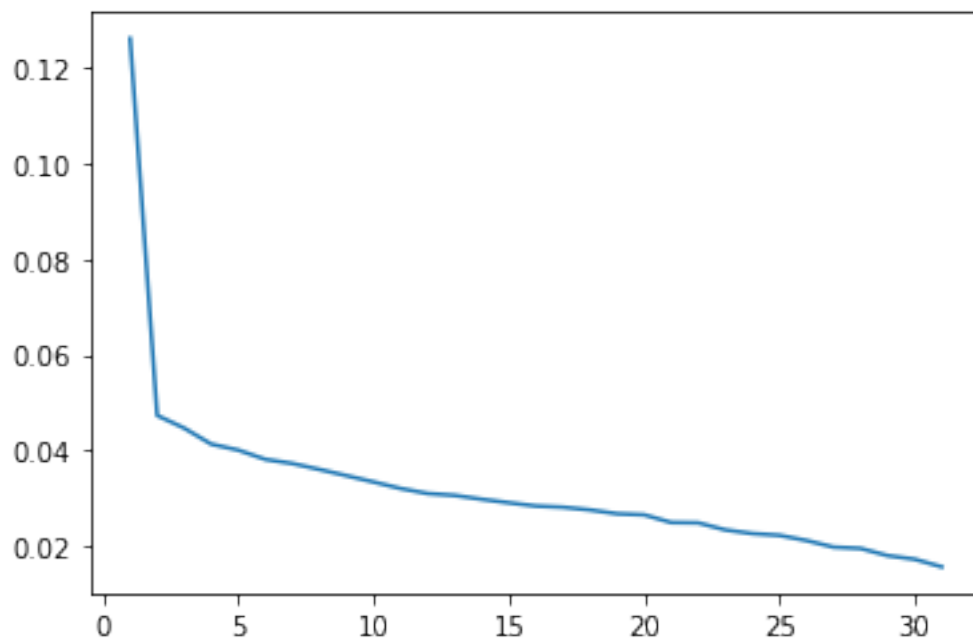


0.2 Question 2e

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 each principal component using the data from 2d.**

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

```
In [101]: np.arange(1,32)
          s**2
          sns.lineplot(x=np.arange(1,32), y=((s**2)/992)/(np.sum(s**2)/(992)))
          plt.show()
```



0.3 Question 3a

What does each row in `df_clean` represent?

each row represents an individual state's election results (whether it was Democratic or Republican) for the election years from 1972 to 2020 for all 51 states

Unfortunately, we have two problems:

1. There is a lot of overplotting, with only 28 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.

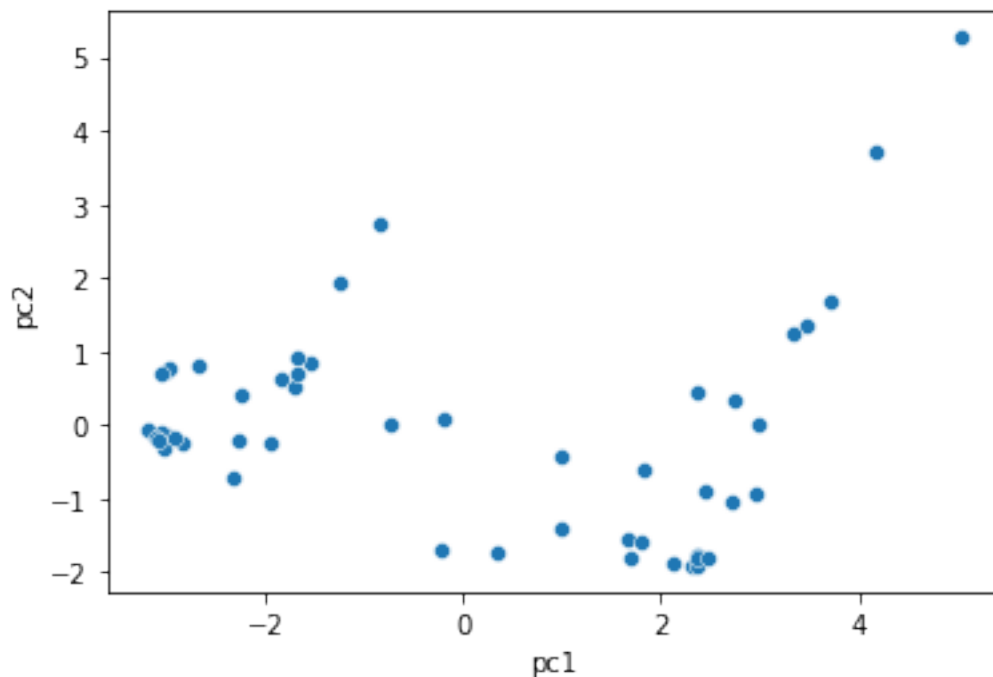
In the cell below, create a new dataframe `first_2_pcs_jittered` with a small amount of random noise added to each principal component. In this same cell, create a scatterplot.

The amount of noise you add should not significantly affect the appearance of the plot, it should simply serve to separate overlapping observations. Don't get caught up on the exact details of your noise generation, it's fine as long as your plot looks roughly the same as the original scatterplot.

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

```
In [111]: 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")
```

```
Out[111]: <AxesSubplot:xlabel='pc1', ylabel='pc2'>
```



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.'

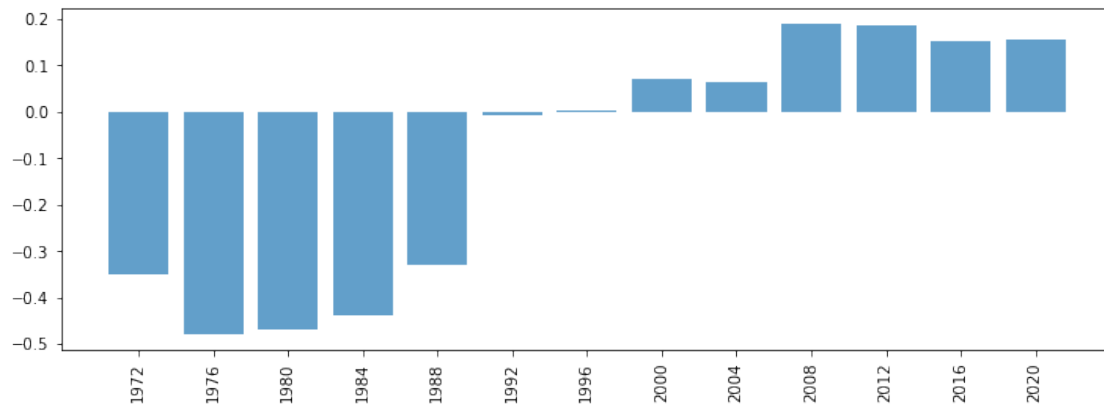
Clusters of states that vote similarly such as alabama, mississippi, south carolina which are generally red states vs california and conneticut which are generally blue states. The cluster isn't particularly surprising as each state has their past voting pattern.

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.

The plot shows that D.C. votes a lot differently compared to the rest of the states. The plot also shows where the swing states are as they are separated from the other clusters as well.

In the cell below, plot the the 2nd row of V^T .

```
In [114]: with plt.rc_context({"figure.figsize": (12,4)}):  
          plot_pc(list(df_numerical.columns), vt_q3,1)
```



0.4 Question 3h

Using your plots from question 3g 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 consensus 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).

the larger the **pc1** values are, the less likely the state would vote for the Republican party. This means the smaller the **pc1** values, the more likely the state would vote republican. in my interpretation, the larger the **pc2** value, the more likely the state would align with a singular party for the majority of elections. In other words, the larger the **pc2** value, the less likely it would be a swing state. As a result, the smaller the **pc2** value, the the more likely the state would switch parties between elections.

0.5 Question 3i

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 i th 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 Data 100 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 [116]: plt.plot(np.arange(1,14), s_q3**2/sum(s_q3**2))
plt.xticks(np.arange(1,14), np.arange(1,14))
plt.xlabel('ith PC')
plt.ylabel('Fraction of Variance')
```

```
Out[116]: Text(0, 0.5, 'Fraction of Variance')
```

