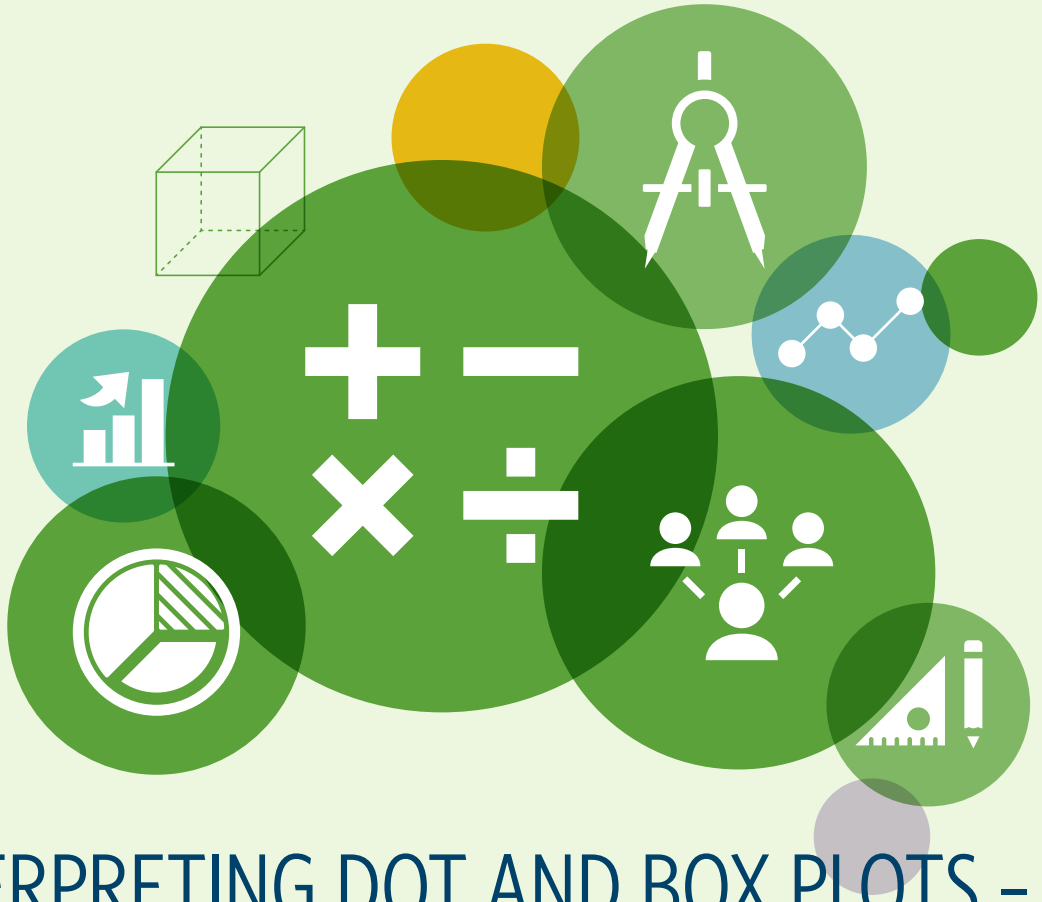


INTERPRETING DOT AND BOX PLOTS – HOW HAS THE U.S. HOUSE OF REPRESENTATIVES CHANGED OVER TIME?

TEACHER VERSION

Subject Level:
Middle School Math

Grade Level:
6

Approx. Time Required:
60 minutes

Learning Objectives:

- Students will be able to create frequency tables, dot plots, and box plots from data.
- Students will be able to compare, interpret, and analyze dot and box plots by focusing on the center, shape, and spread of the distributions.
- Students will be able to summarize changes in the number of seats in the U.S. House of Representatives allocated to each state between 1940 and 2010.

Activity Description

Students will create frequency tables, dot plots, and box plots using census data to learn how each state's number of members in the U.S. House of Representatives changed between 1940 and 2010. Students will also briefly examine a color-coded map to learn how apportionment changed in each state from 2000 to 2010.

Suggested Grade Level:
6

Approximate Time Required:
60 minutes

Learning Objectives:

- Students will be able to create frequency tables, dot plots, and box plots from data.
- Students will be able to compare, interpret, and analyze dot and box plots by focusing on the center, shape, and spread of the distributions.
- Students will be able to summarize changes in the number of seats in the U.S. House of Representatives allocated to each state between 1940 and 2010.

Topics:

- Box plots
- Center
- Dot plots
- Shape
- Spread

Skills Taught:

- Analyzing data
- Creating a box plot
- Creating a dot plot
- Creating frequency tables

Materials Required

- The student version of this activity, 10 pages; it contains images that should be printed in color.
- Teacher computer with Internet access and a projector to display web sites
- Rulers

A graphing calculator or other graphing technology (e.g. Microsoft Excel) is optional.

Activity Items

The following items are part of this activity. Items, their data sources, and any relevant instructions for viewing the source data online appear at the end of this teacher version.

- Item 1: Apportionment of the U.S. House of Representatives Based on the 2010 Census
- Item 2: Number of Seats in the U.S. House of Representatives for Each State in 1940 and 2010

For more information to help you introduce your students to the U.S. Census Bureau, read "*Census Bureau 101 for Students*." This information sheet can be printed and passed out to your students as well.

Standards Addressed

See charts below. For more information, read "*Overview of Education Standards and Guidelines Addressed in Statistics in Schools Activities*."

Common Core State Standards for Mathematics

Standard	Domain	Cluster
CCSS.MATH.CONTENT.6.SP.B.4 Display numerical data in plots on a number line, including dot plots, histograms, and box plots.	6 SP – Statistics & Probability	Summarize and describe distributions.
CCSS.MATH.CONTENT.6.SP.B.5.C Summarize numerical data sets in relation to their context, such as by: Giving quantitative measures of center (median and/or mean) and variability (interquartile range and/or mean absolute deviation), as well as describing any overall pattern and any striking deviations from the overall pattern with reference to the context in which the data were gathered.	6 SP – Statistics & Probability	Summarize and describe distributions.

Standard	Domain	Cluster
CCSS.MATH.CONTENT.6.SP.B.5.D Summarize numerical data sets in relation to their context, such as by: Relating the choice of measures of center and variability to the shape of the data distribution and the context in which the data were gathered.	6 SP – Statistics & Probability	Summarize and describe distributions.

Common Core State Standards for Mathematical Practice

Standard
CCSS.MATH.PRACTICE.MP4. Model with mathematics. Students will model census data using frequency tables, dot plots, and box plots.
CCSS.MATH.PRACTICE.MP5. Use appropriate tools strategically. Students will use graph templates and/or graphing technology to create dot plots and box plots.

National Council of Teachers of Mathematics' Principles and Standards for School Mathematics

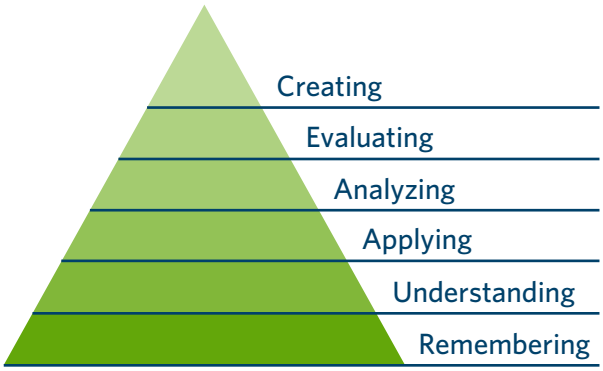
Content Standard	Students should be able to:	Expectation for Grade Band
Data Analysis and Probability	Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them.	Select, create, and use appropriate graphical representations of data, including histograms, box plots, and scatterplots.
Data Analysis and Probability	Select and use appropriate statistical methods to analyze data.	Find, use, and interpret measures of center and spread, including mean and interquartile range.

Guidelines for Assessment and Instruction in Statistics Education

GAISE	Level A	Level B	Level C
Formulate Questions	X		
Collect Data			
Analyze Data		X	
Interpret Results		X	

Bloom's Taxonomy

Students will ***create*** and ***analyze*** frequency tables, box plots, and dot plots.



Teacher Notes

Before the Activity

Students must understand the following key terms:

- **Median** – a measure of center in a set of numerical data, identified as the value appearing at the middle of a sorted version of the list (or the mean of the two middle values if the sorted list contains an even number of values)
- **First quartile (Q_1)** – also known as lower quartile, the value that divides a sorted data set into the smallest 25 percent of the data and the largest 75 percent
- **Third quartile (Q_3)** – also known as upper quartile, the value that divides a sorted data set into the smallest 75 percent of the data and the largest 25 percent
- **Frequency table** – a way to organize a data set to show the number of times each data point appears in it
- **Dot plot** – a graph, also known as a line plot, in which each data point is shown as a dot or other type of mark above a number line
- **Box plot** – a graph that plots the median, quartiles, and extremes of a data set and uses a box to show the middle 50 percent of the data
- **Interquartile range (IQR)** – a measure of variability in a set of numerical data that is the distance between the first and third quartiles of the data set
- **5-number summary** – a summary that provides information about a data set and contains five values: the minimum (smallest value), first quartile, median (middle value), third quartile, and maximum (largest value)
- **Outlier** – a data point that is well outside of the expected range of values or does not follow the overall pattern of the other data points
- **U.S. House of Representatives** – one of the two legislative bodies of the U.S. Congress (the other is the Senate) established in Article I of the U.S. Constitution, with its members elected every two years and states allotted one or more seats based on their populations
- **Apportionment** – the process of dividing the 435 seats in the U.S. House of Representatives among the 50 states according to each state's population, which is determined by the decennial census; at the conclusion of each census, the results are used to calculate the number of House memberships to which each state is entitled.

Students should have the following skills:

- Ability to create dot plots; teachers should review common errors students make when creating these graphs, such as messily stacking the dots and spacing them unevenly.
- Ability to create box plots; teachers should review common errors students make when creating these graphs, such as incorrectly including or excluding the median in quartile calculations.

Teachers should tell students that seats in the U.S. House of Representatives are apportioned after every decennial census. Teachers could refer to the Census Bureau 101 one-pager mentioned earlier for more information about the decennial census. Teachers should also show students this two-minute Census Bureau video (*www.youtube.com/watch?v=RUCnb5_HZc0*) about apportionment. For more information about apportionment, teachers could go here (*www.census.gov/topics/public-sector/congressional-apportionment.html*) or here (*www.census.gov/history/www/reference/apportionment*).

During the Activity

Teachers should monitor students as they work.

Teachers may choose to have students use a graphing calculator or other graphing technology to create their box plots in question 6. Teachers should be aware that some software programs use different methods for calculating quartiles, which may generate different values than those provided in the sample student answers (derived from TI Teacher Software).

To simplify this activity, teachers could direct students to work in pairs, with each partner creating one dot plot and one box plot, using the same scale on their number lines. Each pair of students could work together to compare and analyze their graphs.

After the Activity

Teachers should ask students to share their news articles from question 8 and should lead a class discussion about the various ways these data could be used in real-life situations.

Extension Ideas

- Teachers could change question 6 so that students have to identify any outliers mathematically and create modified box plots, where outliers are plotted as individual data points.
- Teachers could have students use data from Page 2 of this document (*www.census.gov/prod/cen2010/briefs/c2010br-08.pdf*) to create a line graph that shows the changes in their state's number of representatives from one decade to the next.
- Teachers could ask students to research and report on the apportionment history of their state, from the time it became a state to the present.
- Teachers could have students color in a blank map of the United States to show the changes in apportionment between 1940 and 2010, similar to the **Item 1** map that shows the changes in apportionment between 2000 and 2010.

To address GAISE Level C, teachers could direct students to:

- Use measures of variability to compare subsets of data, not just the dot and box plots of the original data.
- Formulate their own questions and conduct further analysis by using data for other years, focusing on data for their state, or focusing on the census-defined geographic regions of the United States (*www2.census.gov/geo/pdfs/maps-data/maps/reference/us_regdiv.pdf*).
- Investigate which state had the largest percentage of growth or decline in terms of apportionment.

Student Activity

Click ***here*** to download a printable version for students.

Activity Items

The following items are part of this activity and appear at the end of this student version.

- Item 1: Apportionment of the U.S. House of Representatives Based on the 2010 Census
- Item 2: Number of Seats in the U.S. House of Representatives for Each State in 1940 and 2010

Student Learning Objectives

- I will be able to create frequency tables, dot plots, and box plots from data.
- I will be able to compare, interpret, and analyze dot and box plots by focusing on the center, shape, and spread of the distributions.
- I will be able to summarize changes in the number of seats in the U.S. House of Representatives allocated to each state between 1940 and 2010.

In this activity, you will create and analyze tables and graphs to figure out how different states' numbers of seats in the U.S. House of Representatives have changed over time.

Answer the following questions by examining **Item 1: Apportionment of the U.S. House of Representatives Based on the 2010 Census**, which labels each state with the number of representatives it had in 2010 and which uses different colors to show how this number changed from 2000.

1. How many representatives did your state have in 2010?

   Student answers will vary depending on the state.

2. Which state had the most representatives in 2010, and how many did it have?

   California, 53

3. How many states had only one representative? Which states were they?

   Seven states had only one representative: Alaska, Delaware, Montana, North Dakota, South Dakota, Vermont, and Wyoming.

Now let's go further back in time, to 1940, before World War II. Look at **Item 2: Number of Seats in the U.S. House of Representatives for Each State in 1940 and 2010** to answer the following questions and prompts:

1. Why do you think there are there no numbers for Alaska and Hawaii in 1940?

   Student answers may vary. The correct answer is that Alaska and Hawaii were not states in 1940. Teachers may want to assist students in answering this question.

2. Complete the frequency tables for 2010 and 1940.

2010 Frequency Table	
Number of Representatives	**Frequency (Number of States)**
1	**7**
2	**5**
3	**3**
4	**6**
5	**3**
6	**2**
7	**3**
8	**4**
9	**4**
10	**1**
11	**1**
12	**1**
13	**1**
14	**2**
15	**0**

1940 Frequency Table	
Number of Representatives	**Frequency (Number of States)**
1	**4**
2	**9**
3	**1**
4	**3**
5	**0**
6	**7**
7	**2**
8	**3**
9	**4**
10	**3**
11	**1**
12	**1**
13	**1**
14	**2**
15	**0**

2010 Frequency Table	
Number of Representatives	Frequency (Number of States)
16	1
17	0
18	2
19	0
20	0
21	0
22	0
23	0
24	0
25	0
26	0
27	2
28	0
29	0
30	0
31	0
32	0
33	0
34	0

1940 Frequency Table	
Number of Representatives	Frequency (Number of States)
16	0
17	1
18	0
19	0
20	0
21	1
22	0
23	2
24	0
25	0
26	1
27	0
28	0
29	0
30	0
31	0
32	0
33	1
34	0

2010 Frequency Table	
Number of Representatives	Frequency (Number of States)
35	0
36	1
37	0
38	0
39	0
40	0
41	0
42	0
43	0
44	0
45	0
46	0
47	0
48	0
49	0
50	0
51	0
52	0
53	1

1940 Frequency Table	
Number of Representatives	Frequency (Number of States)
35	0
36	0
37	0
38	0
39	0
40	0
41	0
42	0
43	0
44	0
45	1
46	0
47	0
48	0
49	0
50	0
51	0
52	0
53	0

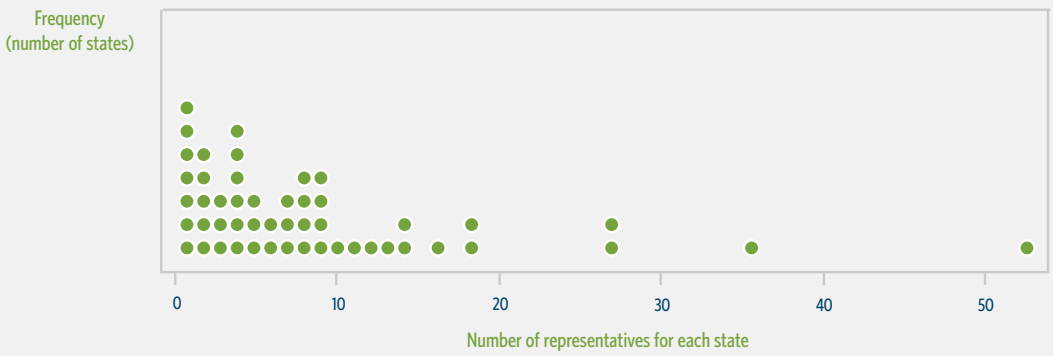
2010 Frequency Table	
Number of Representatives	**Frequency (Number of States)**
Total	**50**

1940 Frequency Table	
Number of Representatives	**Frequency (Number of States)**
Total	**48**

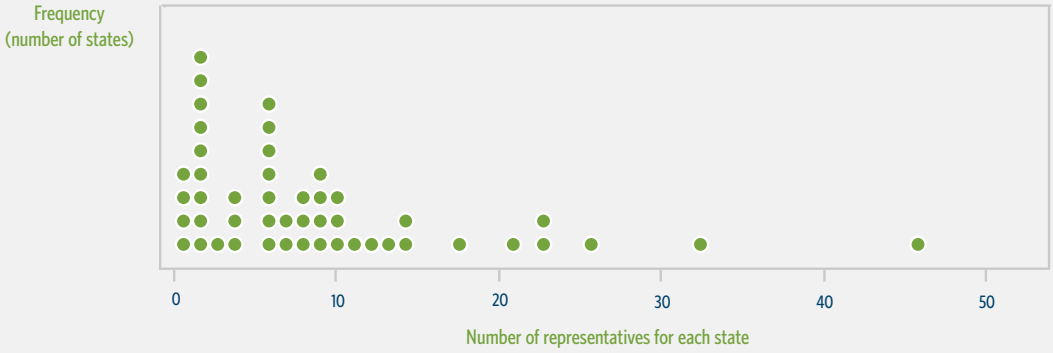
3. Refer to your frequency tables to create one dot plot for the 2010 data and another for the 1940 data. Use one dot for every state, add a title to each graph, and label your horizontal axes.

Student dot plots should look similar to:

U.S. House of Representatives Apportionment by State: 2010



U.S. House of Representatives Apportionment by State: 1940



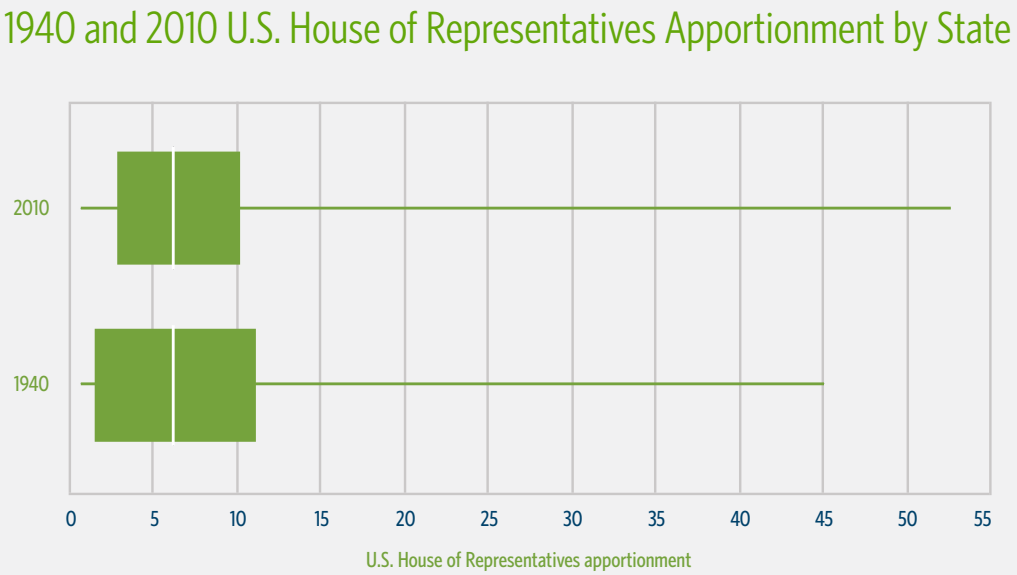
4. Look at your dot plots. What similarities and differences do you notice?

   Student answers will vary but could include: The largest number of representatives in 2010 (53) was more than the number in 1940 (45). The smallest number for both years was 1. There are clusters between 0 and 10 representatives for both 1940 and 2010.

5. Use your frequency tables from question 2 to calculate the 5-number summary, range, and interquartile range (IQR) for each data set.

	2010	1940
Minimum	1	1
Q_1	3	2
Median	6	6.5
Q_3	10	10.5
Maximum	53	45
Range	52	44
IQR	7	8.5

6. Use your five-number summaries to create a box plot for each year of data on the template below, one above the other. Be sure to title the graph and use a ruler to make each box plot neat.



7. What do you notice when you compare your box plots?

   Student answers will vary but could include:

   - **The box plot for 1940 is wider than the box plot for 2010.**
   - **The 2010 box plot shows a higher maximum and wider range than the 1940 box plot.**
   - **The minimums for 1940 and 2010 are the same, and the medians are almost the same.**
   - **Both box plots show a clustering of data at the lower values, with a long whisker at the higher values.**

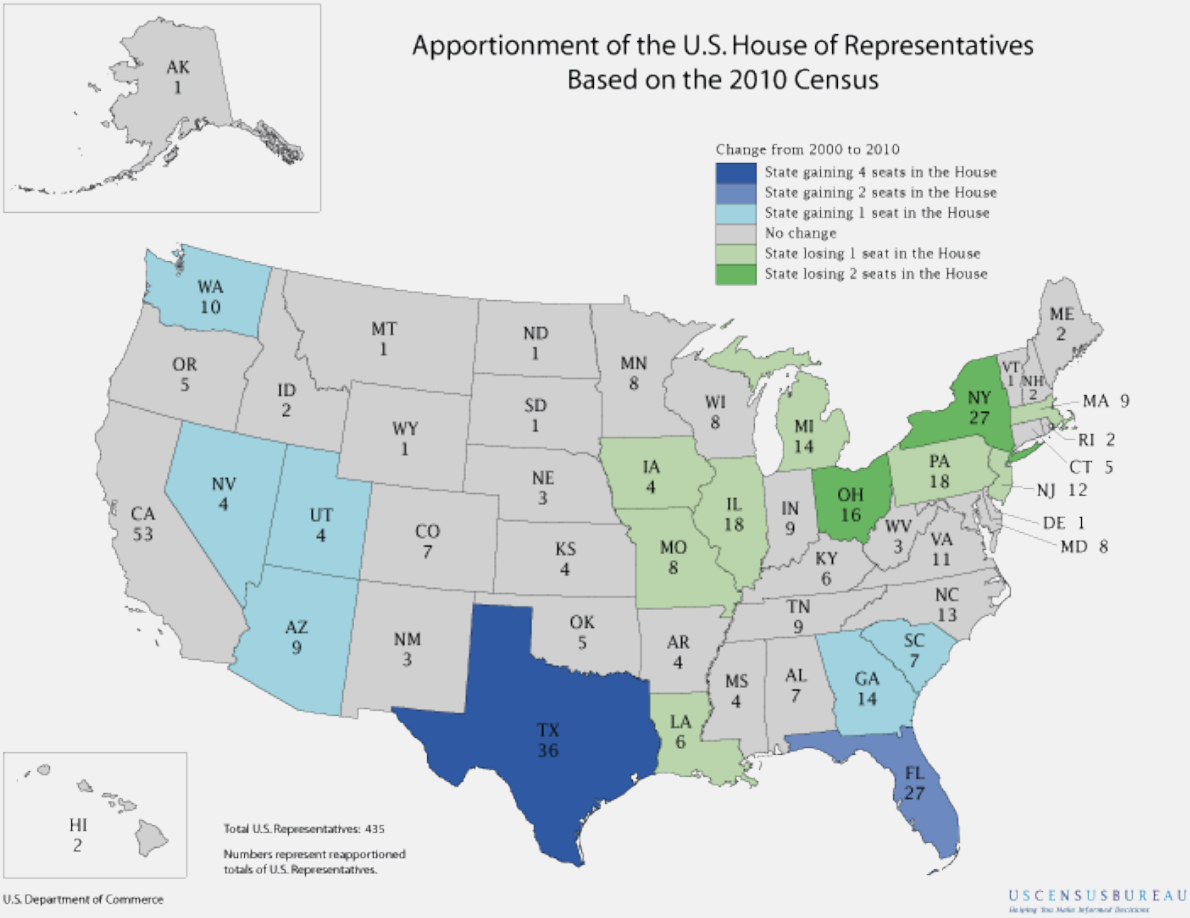
8. Using what you know about U.S. history and referring to your dot and box plots, write a headline and three-paragraph news article: Use your first paragraph to discuss 1940 apportionment, your second paragraph to discuss 2010 apportionment, and your third paragraph to discuss any changes in apportionment that occurred between 1940 and 2010 and why you think they happened.

   Student articles will vary but should connect apportionment in the two years with shifts in state populations over time. Possible headlines include:

   - **Why did so many Midwesterners move away?**
   - **Why did so many people move to Florida?**
   - **The most populous state in 2010 was California**

Item 1: Apportionment of the U.S. House of Representatives Based on the 2010 Census

www.census.gov/history/img/2010apportionment-map.gif



Item 2: Number of Seats in the U.S. House of Representatives for Each State in 1940 and 2010

	1940	Pop. 1940	2010	Pop. 2010
Alabama	9	2,832,961	7	4,779,736
Alaska	N/A	72,524	1	710,231
Arizona	2	499,261	9	6,392,017
Arkansas	7	1,949,387	4	2,915,918
California	23	6,907,387	53	37,253,956
Colorado	4	1,123,296	7	5,029,196
Connecticut	6	1,709,242	5	3,574,097
Delaware	1	266,505	1	897,934
Florida	6	1,897,414	27	18,801,310
Georgia	10	3,123,723	14	9,687,653
Hawaii	N/A	423,330	2	1,360,301
Idaho	2	524,873	2	1,567,582
Illinois	26	7,897,241	18	12,830,632
Indiana	11	3,427,796	9	6,483,802
Iowa	8	2,538,268	4	3,046,355
Kansas	6	1,801,028	4	2,853,118
Kentucky	9	2,845,627	6	4,339,367
Louisiana	8	2,363,880	6	4,533,372
Maine	3	847,226	2	1,328,361
Maryland	6	1,821,244	8	5,773,552
Massachusetts	14	4,316,721	9	6,547,629
Michigan	17	5,256,106	14	9,883,640
Minnesota	9	2,792,300	8	5,303,925
Mississippi	7	2,183,796	4	2,967,297
Missouri	13	3,784,664	8	5,988,927

	1940	Pop. 1940	2010	Pop. 2010
Montana	2	559,456	1	989,415
Nebraska	4	1,315,834	3	1,826,341
Nevada	1	110,247	4	2,700,551
New Hampshire	2	491,524	2	1,316,470
New Jersey	14	4,160,165	12	8,791,894
New Mexico	2	531,818	3	2,059,179
New York	45	13,479,142	27	19,378,102
North Carolina	12	3,571,623	13	9,535,483
North Dakota	2	641,935	1	672,591
Ohio	23	6,907,612	16	11,536,504
Oklahoma	8	2,336,434	5	3,751,351
Oregon	4	1,089,684	5	3,831,074
Pennsylvania	33	9,900,180	18	12,702,379
Rhode Island	2	713,346	2	1,052,567
South Carolina	6	1,899,804	7	4,625,364
South Dakota	2	642,961	1	814,180
Tennessee	10	2,915,841	9	6,346,105
Texas	21	6,414,824	36	25,145,561
Utah	2	550,310	4	2,763,885
Vermont	1	359,231	1	625,741
Virginia	9	2,677,773	11	8,001,024
Washington	6	1,736,191	10	6,724,540
West Virginia	6	1,901,974	3	1,852,994
Wisconsin	10	3,137,587	8	5,686,986
Wyoming	1	250,742	1	563,626

www.census.gov/prod/cen2010/briefs/c2010br-08.pdf

To view the source data online, click on the link above and go to Page 2.