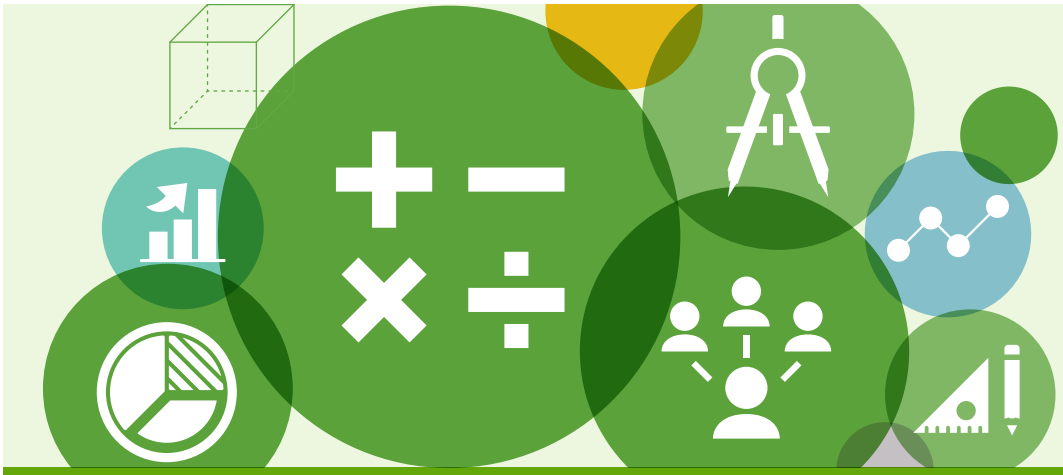


STUDENT VERSION

# EXPLORING SAMPLING VARIABILITY – HIGHER EDUCATION ATTAINMENT ACROSS THE UNITED STATES

## Activity Item

The following item is part of this activity and appears at the end of this student version.

- Item 1: Data Cards

## Student Learning Objectives

- I will be able to create dot plots of sample percentages.
- I will be able to use measures of variability to describe different distributions of random samples.
- I will be able to investigate sampling variability in sample percentages.

NAME:_____ DATE:_____

Statisticians often take samples of data from a population instead of surveying the whole population, which saves time and resources. As long as the sample accurately represents the population, data from them can actually tell statisticians a lot. In this activity, you will explore random samples taken from the same population to understand the impact of sampling variability.

## Part 1 – Record Data and Make a Dot Plot

1. Review the data card your teacher gave you, which has a sample size of 10. What percentage of your states (and the District of Columbia, if it is included on your card) has a population with at least 30 percent holding a bachelor's degree?

   ***Example:***

| | State/District | Percentage of People 25 and Older With Bachelor's Degree |
|---|---|---|
| 1 | Illinois | 32.8 |
| 2 | Kansas | 31.5 |
| 3 | Louisiana | 22.9 |
| 4 | Wyoming | 26.6 |
| 5 | Tennessee | 25.3 |
| 6 | Pennsylvania | 29.0 |
| 7 | Michigan | 27.4 |
| 8 | Colorado | 38.3 |
| 9 | Arkansas | 21.4 |
| 10 | Kentucky | 22.2 |

In the sample at left, there are three states with values over 30 percent.

$$\frac{3}{10} \times 100 = 30\%$$

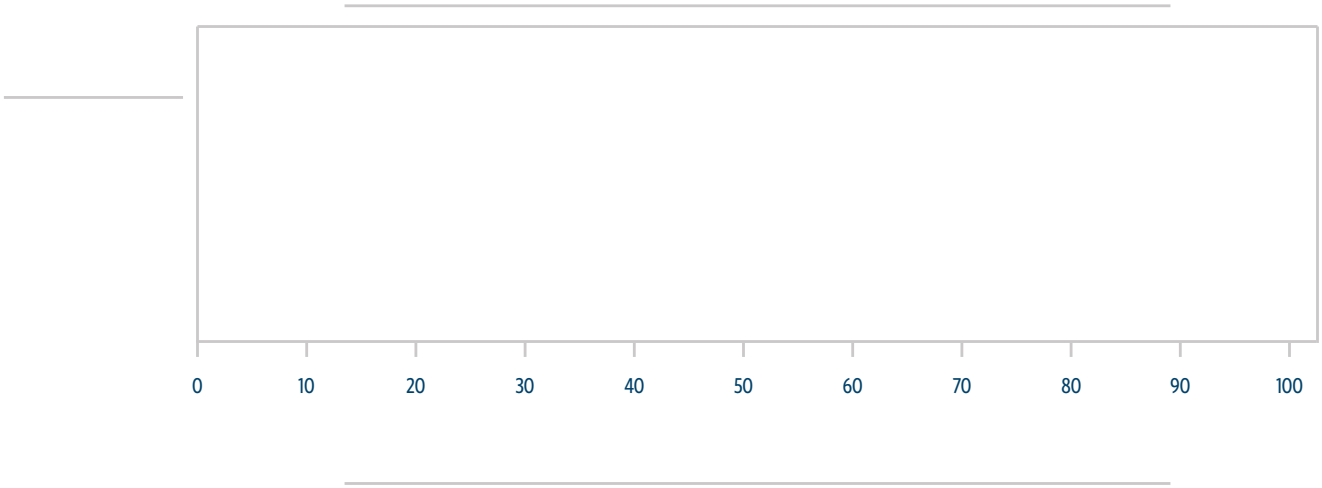
So the sample percentage is 30 percent.

The sample percentage for my data card is _____.

2. As your classmates share their answers to question 1, record them (and yours) in the following tally chart. You should end up with a total of 30 tally marks.

| Sample Percentage | Tally Marks |
|---|---|
| 0% | |
| 10% | |
| 20% | |
| 30% | |
| 40% | |
| 50% | |
| 60% | |
| 70% | |
| 80% | |
| 90% | |
| 100% | |

3. Use your chart to create a dot plot of the sample percentages on the grid below. Add a title that includes the sample size and label the horizontal axis. Note that each dot represents a sample of 10 states (and sometimes the District of Columbia), not just one of them.



4. What is the approximate center of the distribution, and what does this measure show in the context of these data?

5. What is the range of the sample percentages?

6. What do you predict would happen to this center if you analyzed more random samples of this size? Explain.

## Part 2 – Make a Dot Plot With a Larger Sample Size

Now you will work with a group to determine whether the center and spread of a distribution of sample percentages changes if you increase the sample size to 20 (for a total of 15 samples).

Before you get started, cut out all of the data cards from **Item 1: Data Cards**. Now pair the data cards together (data cards 1 and 2, data cards 3 and 4, and so on) until you have paired them all.

1. For each sample of two data cards, calculate the percentage of data points that are at least 30 percent, and record your answers in the chart that follows.

   *Example for one sample:*

| | State/District | Percentage of People 25 and Older With Bachelor's Degree |
|---|---|---|
| 1 | Illinois | 32.8 |
| 2 | Oregon | 30.8 |
| 3 | Vermont | 34.9 |
| 4 | Oklahoma | 24.2 |
| 5 | California | 31.7 |
| 6 | Rhode Island | 30.4 |
| 7 | Wyoming | 26.6 |
| 8 | New Hampshire | 35.0 |
| 9 | Michigan | 27.4 |
| 10 | Delaware | 30.6 |

| | State/District | Percentage of People 25 and Older With Bachelor's Degree |
|---|---|---|
| 1 | Tennessee | 25.3 |
| 2 | Kansas | 31.5 |
| 3 | New Mexico | 26.4 |
| 4 | Massachusetts | 41.2 |
| 5 | Oregon | 30.8 |
| 6 | Minnesota | 34.3 |
| 7 | District of Columbia | 55.0 |
| 8 | Massachusetts | 41.2 |
| 9 | Kansas | 31.5 |
| 10 | Louisiana | 22.9 |

In the sample at left, there are 14 values of at least 30 percent.

$$\frac{14}{20} \times 100 = 70\%$$

| Sample # | Percentage where at least 30% of the population has a bachelor's degree |
|---|---|
| 1 (data cards 1 and 2) | |
| 2 (data cards 3 and 4) | |
| 3 (data cards 5 and 6) | |
| 4 (data cards 7 and 8) | |
| 5 (data cards 9 and 10) | |
| 6 (data cards 11 and 12) | |
| 7 (data cards 13 and 14) | |
| 8 (data cards 15 and 16) | |

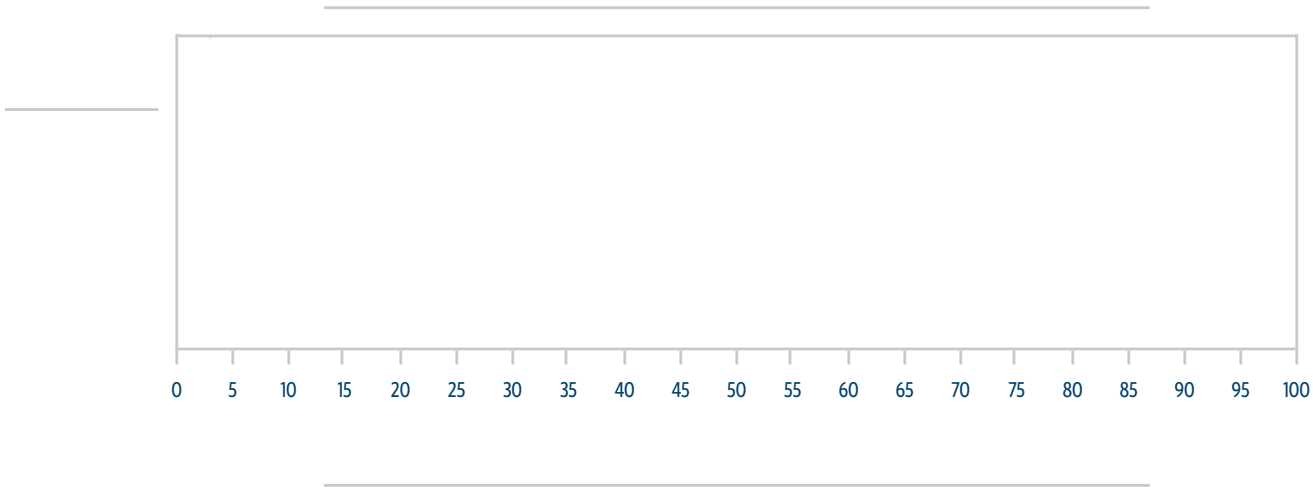
| Sample # | Percentage where at least 30% of the population has a bachelor's degree |
|---|---|
| 9 (data cards 17 and 18) | |
| 10 (data cards 19 and 20) | |
| 11 (data cards 21 and 22) | |
| 12 (data cards 23 and 24) | |
| 13 (data cards 25 and 26) | |
| 14 (data cards 27 and 28) | |
| 15 (data cards 29 and 30) | |

2. Tally up the percentages for all 15 samples above using the chart below.

| Sample Percentage | Tally Marks |
|---|---|
| 0% | |
| 5% | |
| 10% | |
| 15% | |
| 20% | |
| 25% | |
| 30% | |
| 35% | |
| 40% | |
| 45% | |
| 50% | |
| 55% | |

| Sample Percentage | Tally Marks |
|---|---|
| 60% | |
| 65% | |
| 70% | |
| 75% | |
| 80% | |
| 85% | |
| 90% | |
| 95% | |
| 100% | |

3. Use your tally chart to create a dot plot on the grid below. Add a title that includes the sample size and label the horizontal axis. Each dot now represents a sample of 20 states (and sometimes the District of Columbia).




4. What is the approximate center of the distribution?

5. What is the range of the sample percentages?

## Part 3 – Make a Dot Plot With a Smaller Sample Size and Compare Measures of Variability

Now you will determine whether the center and spread of the distribution changes if you decrease the sample size to 5 (for a total of 60 samples).

To begin, cut each of your data cards in half horizontally, after row 5, so you have two sets of 30 cards with five percentages on each.

1. For each of your new samples, calculate the percentage of data points that are at least 30 percent, and record your answers in the chart that follows.

   *Example for one sample:*

| | State/District | Percentage of People 25 and Older With Bachelor's Degree |
|---|---|---|
| 1 | Illinois | 32.8 |
| 2 | Kansas | 31.5 |
| 3 | Louisiana | 22.9 |
| 4 | Wyoming | 26.6 |
| 5 | Tennessee | 25.3 |

In the sample at left, there are two values of at least 30 percent.

$$\frac{2}{5} \times 100 = 40\%$$

| Sample # | Percentage of the states and District of Columbia where at least 30% of the population has a bachelor's degree |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| 7 | |
| 8 | |
| 9 | |
| 10 | |
| 11 | |
| 12 | |
| 13 | |
| 14 | |
| 15 | |
| 16 | |
| 17 | |
| 18 | |
| 19 | |
| 20 | |
| 21 | |
| 22 | |
| 23 | |
| 24 | |
| 25 | |

| Sample # | Percentage of the states and District of Columbia where at least 30% of the population has a bachelor's degree |
|---|---|
| 26 | |
| 27 | |
| 28 | |
| 29 | |
| 30 | |
| 31 | |
| 32 | |
| 33 | |
| 34 | |
| 35 | |
| 36 | |
| 37 | |
| 38 | |
| 39 | |
| 40 | |
| 41 | |
| 42 | |
| 43 | |
| 44 | |
| 45 | |
| 46 | |
| 47 | |
| 48 | |
| 49 | |
| 50 | |

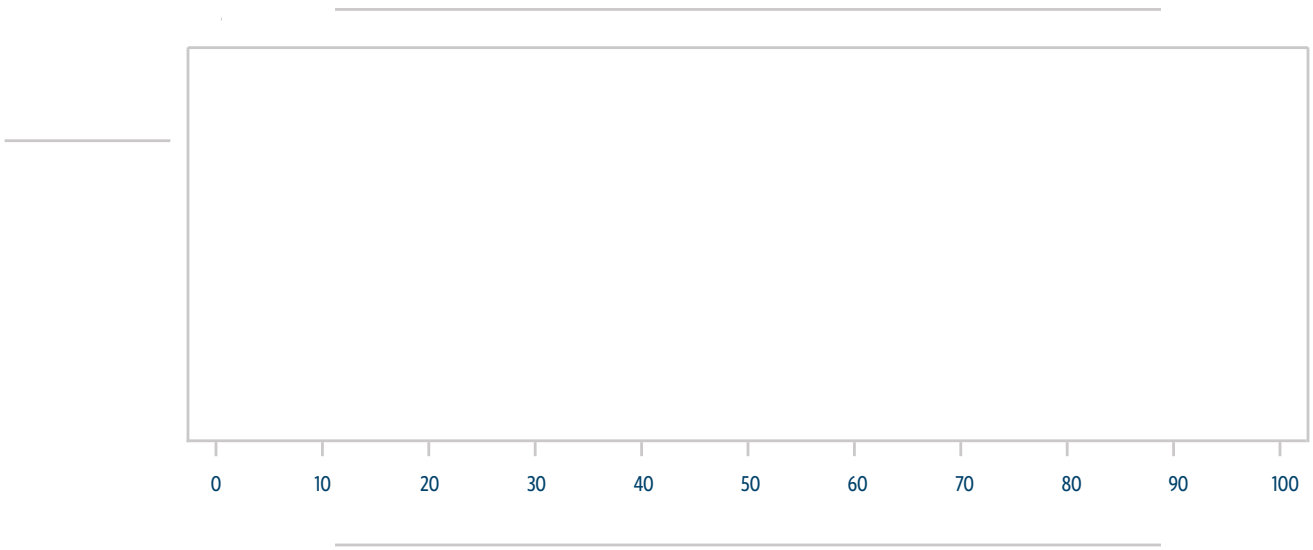
| Sample # | Percentage of the states and District of Columbia where at least 30% of the population has a bachelor's degree |
|---|---|
| 51 | |
| 52 | |
| 53 | |
| 54 | |
| 55 | |

| Sample # | Percentage of the states and District of Columbia where at least 30% of the population has a bachelor's degree |
|---|---|
| 56 | |
| 57 | |
| 58 | |
| 59 | |
| 60 | |

2. Record your group's findings for all 60 samples from the chart above in the tally chart below.

| Sample Percentage | Tally Marks |
|---|---|
| 0% | |
| 10% | |
| 20% | |
| 30% | |
| 40% | |
| 50% | |
| 60% | |
| 70% | |
| 80% | |
| 90% | |
| 100% | |

3. Use the data from your tally chart to make a dot plot of the sample percentages. Add a title that includes the sample size and label the horizontal axis. Each dot now represents a collection of five states (and the District of Columbia, if it applies).




4. What is the approximate center of the distribution?

5. What is the range of the sample percentages?

6. Looking back at the centers and ranges you found for parts 1 and 2, compare these measures of variability for all three sample sizes using the following table.

| Sample size | Number of samples | Approximate Center | Range |
|---|---|---|---|
| 5 | 60 | | |
| 10 | 30 | | |
| 20 | 15 | | |

7. The actual percentage of U.S. states and the District of Columbia in which more than 30 percent of their residents aged 25 and older have bachelor's degrees was 39.2 in 2014. Which sample size (5, 10, or 20) would you use to most accurately estimate this percentage? Explain.

## Part 4 – Apply What You Learned About Sampling

Imagine you want to find out the percentage of students at your school who plan to participate in different types of extracurricular activities next year. Instead of asking each student separately, you can use a sampling method to make predictions.

1. How would you select a random sample of students?

2. What question(s) would you ask each student in the sample?

3. How would you record the data from your sample?

4. How would you communicate your results to others?

5. What would be the advantage of sampling the student body instead of surveying every student individually?

# Item 1: Data Cards

| 1 | State/District | Percentage of People 25 and Older With Bachelor's Degree |
|---|---|---|
| 1 | North Carolina | 28.7 |
| 2 | Pennsylvania | 29.0 |
| 3 | Virginia | 36.7 |
| 4 | North Carolina | 28.7 |
| 5 | Maine | 29.4 |
| 6 | Oregon | 30.8 |
| 7 | Georgia | 29.1 |
| 8 | South Carolina | 26.3 |
| 9 | Florida | 27.3 |
| 10 | Montana | 29.3 |

| | | |
|---|---|---|
| | Louisiana | 22.9 |
| | Oregon | 30.8 |
| | Nevada | 23.1 |
| | Colorado | 38.3 |
| | Kansas | 31.5 |
| | Illinois | 32.8 |
| | Mississippi | 21.1 |
| | Pennsylvania | 29.0 |
| | California | 31.7 |
| | Kansas | 31.5 |

| | | |
|---|---|---|
| | New Hampshire | 35.0 |
| | California | 31.7 |
| | Louisiana | 22.9 |
| | Virginia | 36.7 |
| | Mississippi | 21.1 |
| | Missouri | 27.5 |
| | Ohio | 26.6 |
| | Wyoming | 26.6 |
| | Washington | 33.1 |
| | Arizona | 27.6 |

| 4 | State/District | Percentage of People 25 and Older With Bachelor's Degree |
|---|---|---|
| 1 | Nevada | 23.1 |
| 2 | Washington | 33.1 |
| 3 | Kansas | 31.5 |
| 4 | Nebraska | 29.5 |
| 5 | Vermont | 34.9 |
| 6 | Kansas | 31.5 |
| 7 | Montana | 29.3 |
| 8 | Virginia | 36.7 |
| 9 | Arizona | 27.6 |
| 10 | Alabama | 23.5 |

| 5 | State/District | Percentage of People 25 and Older With Bachelor's Degree |
|---|---|---|
| 1 | Illinois | 32.8 |
| 2 | Oregon | 30.8 |
| 3 | Vermont | 34.9 |
| 4 | Oklahoma | 24.2 |
| 5 | California | 31.7 |
| 6 | Alabama | 23.5 |
| 7 | Minnesota | 34.3 |
| 8 | District of Columbia | 55.0 |
| 9 | Massachusetts | 41.2 |
| 10 | North Dakota | 27.4 |

| 6 | State/District | Percentage of People 25 and Older With Bachelor's Degree |
|---|---|---|
| 1 | Nevada | 23.1 |
| 2 | New Mexico | 26.4 |
| 3 | District of Columbia | 55.0 |
| 4 | South Dakota | 27.8 |
| 5 | Illinois | 32.8 |
| 6 | West Virginia | 19.2 |
| 7 | Montana | 29.3 |
| 8 | California | 31.7 |
| 9 | Oklahoma | 24.2 |
| 10 | Maryland | 38.2 |

# Item 1: Data Cards (Continued)

| 7 | State/District | Percentage of People 25 and Older With Bachelor's Degree |
|---|---|---|
| 1 | Alabama | 23.5 |
| 2 | Delaware | 30.6 |
| 3 | Vermont | 34.9 |
| 4 | Georgia | 29.1 |
| 5 | Colorado | 38.3 |
| 6 | Washington | 33.1 |
| 7 | West Virginia | 19.2 |
| 8 | Oklahoma | 24.2 |
| 9 | Indiana | 24.7 |
| 10 | Wyoming | 26.6 |

| | | |
|---|---|---|
| | Nebraska | 29.5 |
| | Kansas | 31.5 |
| | Minnesota | 34.3 |
| | Missouri | 27.5 |
| | Arkansas | 21.4 |
| | Massachusetts | 41.2 |
| | California | 31.7 |
| | Idaho | 25 |
| | Ohio | 26.6 |
| | District of Columbia | 55.0 |

| | | |
|---|---|---|
| | Tennessee | 25.3 |
| | Oregon | 30.8 |
| | Alabama | 23.5 |
| | District of Columbia | 55.0 |
| | District of Columbia | 55.0 |
| | Utah | 31.1 |
| | California | 31.7 |
| | Vermont | 34.9 |
| | West Virginia | 19.2 |
| | Colorado | 38.3 |

| 10 | State/District | Percentage of People 25 and Older With Bachelor's Degree |
|---|---|---|
| 1 | New Mexico | 26.4 |
| 2 | Florida | 27.3 |
| 3 | Alaska | 28.0 |
| 4 | South Carolina | 26.3 |
| 5 | New York | 34.5 |
| 6 | Indiana | 24.7 |
| 7 | South Dakota | 27.8 |
| 8 | Idaho | 25.0 |
| 9 | Maine | 29.4 |
| 10 | Louisiana | 22.9 |

| 11 | State/District | Percentage of People 25 and Older With Bachelor's Degree |
|---|---|---|
| 1 | Pennsylvania | 29.0 |
| 2 | Michigan | 27.4 |
| 3 | Colorado | 38.3 |
| 4 | Arkansas | 21.4 |
| 5 | Kentucky | 22.2 |
| 6 | Delaware | 30.6 |
| 7 | North Carolina | 28.7 |
| 8 | Michigan | 27.4 |
| 9 | Oklahoma | 24.2 |
| 10 | New Jersey | 37.4 |

| 12 | State/District | Percentage of People 25 and Older With Bachelor's Degree |
|---|---|---|
| 1 | Tennessee | 25.3 |
| 2 | Iowa | 27.7 |
| 3 | New Mexico | 26.4 |
| 4 | Massachusetts | 41.2 |
| 5 | Oregon | 30.8 |
| 6 | Illinois | 32.8 |
| 7 | Wyoming | 26.6 |
| 8 | Tennessee | 25.3 |
| 9 | Kansas | 31.5 |
| 10 | Louisiana | 22.9 |

# Item 1: Data Cards (Continued)

| 13 | State/District | Percentage of People 25 and Older With Bachelor's Degree |
|---|---|---|
| 1 | Hawaii | 31.0 |
| 2 | Kansas | 31.5 |
| 3 | South Dakota | 27.8 |
| 4 | Illinois | 32.8 |
| 5 | Colorado | 38.3 |
| 6 | New Mexico | 26.4 |
| 7 | Nebraska | 29.5 |
| 8 | South Dakota | 27.8 |
| 9 | Michigan | 27.4 |
| 10 | Colorado | 38.3 |

| | | |
|---|---|---|
| | Colorado | 38.3 |
| | Massachusetts | 41.2 |
| | Maine | 29.4 |
| | West Virginia | 19.2 |
| | Colorado | 38.3 |
| | Wisconsin | 28.4 |
| | Illinois | 32.8 |
| | Alaska | 28.0 |
| | Oklahoma | 24.2 |
| | Kentucky | 22.2 |

| | | |
|---|---|---|
| | Florida | 27.3 |
| | Tennessee | 25.3 |
| | Rhode Island | 30.4 |
| | Nebraska | 29.5 |
| | West Virginia | 19.2 |
| | South Carolina | 26.3 |
| | Kentucky | 22.2 |
| | North Dakota | 27.4 |
| | Vermont | 34.9 |
| | Washington | 33.1 |

| 16 | State/District | Percentage of People 25 and Older With Bachelor's Degree |
|---|---|---|
| 1 | Illinois | 32.8 |
| 2 | Washington | 33.1 |
| 3 | Kentucky | 22.2 |
| 4 | Alabama | 23.5 |
| 5 | West Virginia | 19.2 |
| 6 | Colorado | 38.3 |
| 7 | Maine | 29.4 |
| 8 | Tennessee | 25.3 |
| 9 | Massachusetts | 41.2 |
| 10 | Hawaii | 31.0 |

| 17 | State/District | Percentage of People 25 and Older With Bachelor's Degree |
|---|---|---|
| 1 | Idaho | 25.0 |
| 2 | Maryland | 38.2 |
| 3 | Mississippi | 21.1 |
| 4 | Texas | 27.8 |
| 5 | Iowa | 27.7 |
| 6 | Nevada | 23.1 |
| 7 | Missouri | 27.5 |
| 8 | Kentucky | 22.2 |
| 9 | West Virginia | 19.2 |
| 10 | Alabama | 23.5 |

| 18 | State/District | Percentage of People 25 and Older With Bachelor's Degree |
|---|---|---|
| 1 | District of Columbia | 55.0 |
| 2 | Iowa | 27.7 |
| 3 | Delaware | 30.6 |
| 4 | North Dakota | 27.4 |
| 5 | Massachusetts | 41.2 |
| 6 | New Hampshire | 35.0 |
| 7 | New Hampshire | 35.0 |
| 8 | New Jersey | 37.4 |
| 9 | Louisiana | 22.9 |
| 10 | Nevada | 23.1 |

# Item 1: Data Cards (Continued)

| 19 | State/District | Percentage of People 25 and Older With Bachelor's Degree |
|---|---|---|
| 1 | North Carolina | 28.7 |
| 2 | Delaware | 30.6 |
| 3 | Michigan | 27.4 |
| 4 | Oklahoma | 24.2 |
| 5 | Rhode Island | 30.4 |
| 6 | New York | 34.5 |
| 7 | Vermont | 34.9 |
| 8 | New York | 34.5 |
| 9 | Missouri | 27.5 |
| 10 | Maryland | 38.2 |

| | | |
|---|---|---|
| | California | 31.7 |
| | Massachusetts | 41.2 |
| | Wyoming | 26.6 |
| | Washington | 33.1 |
| | Texas | 27.8 |
| | Rhode Island | 30.4 |
| | Wyoming | 26.6 |
| | New Hampshire | 35.0 |
| | Michigan | 27.4 |
| | Delaware | 30.6 |

| | | |
|---|---|---|
| | North Dakota | 27.4 |
| | Kentucky | 22.2 |
| | Nebraska | 29.5 |
| | North Dakota | 27.4 |
| | Washington | 33.1 |
| | Kansas | 31.5 |
| | District of Columbia | 55.0 |
| | Nebraska | 29.5 |
| | Mississippi | 21.1 |
| | Idaho | 25.0 |

| 22 | State/District | Percentage of People 25 and Older With Bachelor's Degree |
|---|---|---|
| 1 | North Carolina | 28.7 |
| 2 | West Virginia | 19.2 |
| 3 | Oregon | 30.8 |
| 4 | Arkansas | 21.4 |
| 5 | Virginia | 36.7 |
| 6 | Massachusetts | 41.2 |
| 7 | Missouri | 27.5 |
| 8 | Montana | 29.3 |
| 9 | South Carolina | 26.3 |
| 10 | Kentucky | 22.2 |

| 23 | State/District | Percentage of People 25 and Older With Bachelor's Degree |
|---|---|---|
| 1 | Maryland | 38.2 |
| 2 | Rhode Island | 30.4 |
| 3 | Vermont | 34.9 |
| 4 | Tennessee | 25.3 |
| 5 | Louisiana | 22.9 |
| 6 | Oklahoma | 24.2 |
| 7 | New Jersey | 37.4 |
| 8 | Rhode Island | 30.4 |
| 9 | Oklahoma | 24.2 |
| 10 | Mississippi | 21.1 |

| 24 | State/District | Percentage of People 25 and Older With Bachelor's Degree |
|---|---|---|
| 1 | Pennsylvania | 29.0 |
| 2 | North Dakota | 27.4 |
| 3 | Michigan | 27.4 |
| 4 | Alabama | 23.5 |
| 5 | Oregon | 30.8 |
| 6 | Ohio | 26.6 |
| 7 | New Hampshire | 35.0 |
| 8 | Indiana | 24.7 |
| 9 | Arkansas | 21.4 |
| 10 | Arizona | 27.6 |

# Item 1: Data Cards (Continued)

| 25 | State/District | Percentage of People 25 and Older With Bachelor's Degree |
|---|---|---|
| 1 | Indiana | 24.7 |
| 2 | North Dakota | 27.4 |
| 3 | District of Columbia | 55.0 |
| 4 | West Virginia | 19.2 |
| 5 | Indiana | 24.7 |
| 6 | Colorado | 38.3 |
| 7 | District of Columbia | 55.0 |
| 8 | Kentucky | 22.2 |
| 9 | Tennessee | 25.3 |
| 10 | New York | 34.5 |

| | | |
|---|---|---|
| | Indiana | 24.7 |
| | Montana | 29.3 |
| | Tennessee | 25.3 |
| | Montana | 29.3 |
| | Alaska | 28.0 |
| | Illinois | 32.8 |
| | Pennsylvania | 29.0 |
| | Iowa | 27.7 |
| | New York | 34.5 |
| | Wyoming | 26.6 |

| | | |
|---|---|---|
| | Colorado | 38.3 |
| | District of Columbia | 55.0 |
| | Idaho | 25.0 |
| | South Carolina | 26.3 |
| | Alabama | 23.5 |
| | Kentucky | 22.2 |
| | Maine | 29.4 |
| | Idaho | 25.0 |
| | Pennsylvania | 29.0 |
| | South Carolina | 26.3 |

| 28 | State/District | Percentage of People 25 and Older With Bachelor's Degree |
|---|---|---|
| 1 | Ohio | 26.6 |
| 2 | Montana | 29.3 |
| 3 | Hawaii | 31.0 |
| 4 | Rhode Island | 30.4 |
| 5 | Oregon | 30.8 |
| 6 | North Dakota | 27.4 |
| 7 | Massachusetts | 41.2 |
| 8 | Rhode Island | 30.4 |
| 9 | Illinois | 32.8 |
| 10 | Iowa | 27.7 |

| 29 | State/District | Percentage of People 25 and Older With Bachelor's Degree |
|---|---|---|
| 1 | Virginia | 36.7 |
| 2 | Iowa | 27.7 |
| 3 | Idaho | 25.0 |
| 4 | Nevada | 23.1 |
| 5 | West Virginia | 19.2 |
| 6 | Georgia | 29.1 |
| 7 | South Dakota | 27.8 |
| 8 | Virginia | 36.7 |
| 9 | Montana | 29.3 |
| 10 | New Jersey | 37.4 |

| 30 | State/District | Percentage of People 25 and Older With Bachelor's Degree |
|---|---|---|
| 1 | District of Columbia | 55.0 |
| 2 | Ohio | 26.6 |
| 3 | District of Columbia | 55.0 |
| 4 | Tennessee | 25.3 |
| 5 | Kansas | 31.5 |
| 6 | Virginia | 36.7 |
| 7 | Connecticut | 38.0 |
| 8 | Mississippi | 21.1 |
| 9 | Idaho | 25.0 |
| 10 | Washington | 33.1 |

**Source:** 2014 American Community Survey 1-Year Estimates
*https://data.census.gov/cedsci/table?q=percent%20bachelors%20degree&g=0100000US.04000.001&hidePreview=true&tid=ACSST1Y2014.S1501*