# Population Parameters with M&M'S®

Anna Bargagliotti
Loyola Marymount University
abargagl@lmu.edu

Jeanie Gibson
Hutchison School
jgibson@hutchisonschool.org

Project-SET
www.project-set.com

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## Overview of Lesson

This activity allows students to set up a statistical question to explore a population parameter of interest and, more specifically, perform a hands-on investigation to investigate a claim about a population proportion. Students will be divided into pairs or small groups and presented with the claim from Mars, Incorporated *that the proportion of green M&M'S® in all milk chocolate M&M'S® produced by the company is 16%.* Students will then be asked to formulate the statistical question that needs to be answered in order to prove or disprove the claim made by Mars, Inc. They will be asked to think about how they could possibly use a very large class container of M&M'S® to investigate the validity of the claim. In the process of performing the outlined investigation, students will be exploring the relationships between a population, population parameters, random samples and statistics. They will draw samples of M&M'S® from a class container to obtain sample proportions, and see summary statistics illustrated on a "class dot plot." By the end of the investigation students will be able to informally relate a sample statistic to a known population parameter and will be asked to extend the concept to situations where the population parameter is not known.

## GAISE Components

This activity follows all four components of statistical problem solving put forth in the *Guidelines for Assessment and Instruction in Statistics Education* (GAISE) *Report.* The four components are: formulate a question, design and implement a plan to collect data, analyze the data by measures and graphs, and interpret the results in the context of the original question. This is a GAISE Level B Activity.

## Common Core State Standards for Mathematical Practice

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.

**Common Core State Standards Grade Level Content (High School)**

S-ID. 1. Represent data with plots on the real number line (dot plots, histograms, and box plots).

S-IC. 1. Understand statistics as a process for making inferences about population parameters based on a random sample from that population.

S-IC. 4. Use data from a sample survey to estimate a population mean or proportion; develop a margin of error through the use of simulation models for random sampling.

**NCTM Principles and Standards for School Mathematics**

**Data Analysis and Probability Standards for Grades 9-12**

**Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them:**

- compute basic statistics and understand the distinction between a statistic and a parameter.

**Develop and evaluate inferences and predictions that are based on data:**

- use simulations to explore the variability of sample statistics from a known population and to construct sampling distributions;
- understand how sample statistics reflect the values of population parameters and use sampling distributions as the basis for informal inference.

**Prerequisites**

Prior to completing this activity students should be able to identify the population and sample in a sample survey and in other situations involving random sampling. They should also understand that information from a sample is used to draw conclusions about the entire population. They will also have learned to distinguish between a parameter and a statistic and should have an understanding of dot plots and how they are used to represent quantitative data. Students should be very comfortable with the concept of a proportion and how to calculate a sample proportion.

**Learning Targets**

After completing the activity, students will have a more in-depth understanding of how a sample statistic is used to estimate a population parameter. They will also be familiar with the fact that different samples give different summary statistics. Students will understand both the method of constructing a dot plot and how the plot can be used to display the sampling distribution of a statistic. They will also have an informal understanding of how sample size affects the sampling distribution.

**Time Required**

The time required for this activity is approximately 60 minutes.

**Materials Required**

For this activity, students will need a pencil, paper and sticky notes. The instructor will provide a large class container of M&M'S® and the Activity Worksheet.

**Instructional Lesson Plan**

**The GAISE Statistical Problem-Solving Procedure**

**I. Formulate Question(s)**

Before beginning the activity, the teacher may wish to review the definitions of population, sample, population parameter, and sample statistic, reinforcing student understanding of these foundational concepts for the lesson. Begin the activity by presenting the claim made by Mars, Inc. that 16% of all milk chocolate M&M'S® produced are green. After the claim is presented students are divided into either pairs or small groups and the teacher will pass out the Activity Worksheet. The question of interest for the activity is:

**Is the claim that 16% of milk chocolate M&M'S® produced by Mars, Inc. are green a valid claim?**

Students will be asked to formulate the specific question that needs to be answered in order to prove/disprove the claim by Mars, Inc. They will be referred back to the concepts of population, population parameter, sample and sample statistic to be used in their question formulation.

**II. Design and Implement a Plan to Collect the Data**

After formulating the question to be answered, students will be asked to consider how random sampling could be used to explore the population parameter of interest (proportion of green M&M'S®). They will be presented with a large classroom bin of M&M'S® and asked how they could possibly use it to help with their investigation. After students have discussed the possibilities they will be guided through an investigation with a series of questions on the Activity Worksheet. They will first calculate the proportion of green M&M'S® in a single sample of M&M'S®. They will record the proportion on a sticky note and the class will construct a dot plot on the board showing the approximate sampling distribution of the proportion of green M&M'S® in a sample of a fixed size of M&M'S®. They will then take another sample of M&M'S® and calculate the proportion of green M&M'S® in the total number of M&M'S® from both sample selections. A second dot plot will be constructed on the board showing the sampling distribution of the proportion of green M&M'S® from two samples combined.

**III. Analyze the Data**

At this point students will be performing an informal analysis of the data displayed on the two class dot plots. They will first be asked to use the two plots to estimate the proportion of green M&M'S®. They will then be asked to compare the dot plots to analyze the effects of a larger

sample size. The estimate of the proportion of green M&M'S® should be approximately 16% and the increased sample size should decrease the spread of the distribution.

Sample outcomes are shown in the tables on the next page. The data in the sample outcomes were collected from sampling from a large bin of M&M'S® with exactly 16% green M&M'S® in the bin. The bin should contain at least 500 M&M'S® (a typical 1.69 ounce bag of M&M'S® contains around 50 candies). Teachers should note that the proportion of green M&M'S® in a large bag of M&M'S® could vary from the 16% value. Thus, to make the lesson more tractable for students in the class, a teacher should prepare the bin ahead of time accordingly. In other words, a teacher should have a large bin of M&M'S® containing 16% green M&M'S® for students to sample from ready in the classroom prior to beginning the lesson.

## SAMPLE DATA ANALYSIS

Twenty samples were collected for sample sizes $n = 30$ and $n = 60$. The results and corresponding dot plots are shown below.

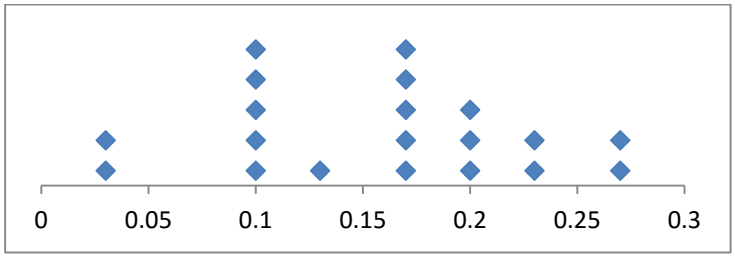
**Sample Proportions for $n = 30$**

| Sample # | Proportion of green M&M'S® |
|---|---|
| 1 | 5/30 = 0.17 |
| 2 | 6/30 = 0.20 |
| 3 | 3/30 = 0.10 |
| 4 | 8/30 = 0.27 |
| 5 | 3/30 = 0.10 |
| 6 | 3/30 = 0.10 |
| 7 | 6/30 = 0.20 |
| 8 | 5/30 = 0.17 |
| 9 | 7/30 = 0.23 |
| 10 | 3/30 = 0.10 |
| 11 | 3/30 = 0.10 |
| 12 | 4/30 = 0.13 |
| 13 | 7/30 = 0.23 |
| 14 | 5/30 = 0.17 |
| 15 | 5/30 = 0.17 |
| 16 | 1/30 = 0.03 |
| 17 | 6/30 = 0.20 |
| 18 | 8/30 = 0.27 |
| 19 | 1/30 = 0.03 |
| 20 | 5/30 = 0.17 |

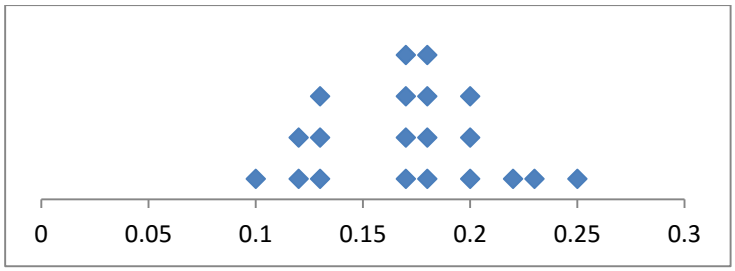
**Sample Proportions for $n = 60$**

| Sample # | Proportion of green M&M'S® |
|---|---|
| 1 | 12/60 = 0.20 |
| 2 | 15/60 = 0.25 |
| 3 | 14/60 = 0.23 |
| 4 | 7/60 = 0.12 |
| 5 | 10/60 = 0.17 |
| 6 | 10/60 = 0.17 |
| 7 | 11/60 = 0.18 |
| 8 | 7/60 = 0.12 |
| 9 | 8/60 = 0.13 |
| 10 | 10/60 = 0.17 |
| 11 | 8/60 = 0.13 |
| 12 | 11/60 = 0.18 |
| 13 | 6/60 = 0.10 |
| 14 | 11/60 = 0.18 |
| 15 | 12/60 = 0.20 |
| 16 | 10/60 = 0.17 |
| 17 | 12/60 = 0.20 |
| 18 | 11/60 = 0.18 |
| 19 | 13/60 = 0.22 |
| 20 | 8/60 = 0.13 |

**Dot Plots for Sample Proportions of Green M&M'S® for Sample Sizes *n* = 30 and *n* = 60**




**Proportion of Green M&M's ®**
**Sample Size *n* = 30**




**Proportion of Green M&M's ®**
**Sample Size *n* = 60**

## IV. Interpret the Results

During the activity students were asked if the information on the dot plots seemed to support the claim that 16% of all milk chocolate M&M'S® produced are green. Even though the proportion of green M&M'S® will vary considerably from sample to sample, the data displayed on the dot plot should support the claim.

Students will be asked to answer the following questions on the activity sheet as they work through the sampling procedure and analysis. Answers to the questions are discussed below.

**STEP 1:** Preliminary questions.

1. What is the specific question(s) that needs to be addressed in your investigation?
   Answer: After reading the question of interest on the activity sheet, students should recognize that the question to be addressed is, "What proportion of all milk chocolate M&M'S® produced by Mars, Inc. are green?" To set up the question, students should recognize that the proportion of all milk chocolate M&M'S® that are green is a population parameter, with the population being all milk chocolate M&M'S® produced by Mars, Inc.

2. How does this question relate to the background information at the beginning of the activity? Be sure to use some of the bold-faced terms in your answer.
   Answer: Students should see that this question relates to the background information in that it involves a **population parameter** (the proportion of green M&M'S®) and a **population** (all milk chocolate M&M'S® produced by Mars, Inc.).

3. What is the population of interest in the investigation?
   Answer: The population of interest is all milk chocolate M&M'S® produced by Mars, Inc. It is important that students recognize that this includes more than the number of M&M'S® in a large bag of M&M'S®, the M&M'S® in a certain grocery store, or even the number of M&M'S® produced by Mars, Inc. in a given time period, but ALL milk chocolate M&M'S® produced by Mars, Inc.

4. What is the population parameter of interest in the investigation?
   Answer: The population parameter of interest is the proportion of green M&M'S®. Students should be able to distinguish between the proportion and other possible quantities or parameters such as the number of green M&M'S® or the mean number of green M&M'S®.

5. Why can we not realistically calculate the population parameter of interest directly?
   Answer: It is important that students recognize how large a quantity of M&M'S® would be involved in calculating the proportion of green M&M'S® in ALL milk chocolate M&M'S® produced by Mars, Inc. They should also realize that production is an ongoing process. Both of these factors would make it impossible to count all M&M'S® produced by Mars, Inc. and determine the proportion of green M&M'S®.

6. How could the concept of random sampling be used to investigate the population parameter of interest?
   Answer: In answering this question students should mention that random sampling is a practical, reasonable way to gather information that can be used to help draw conclusions about a population of interest. They should point out that in this activity, a sample of M&M'S® can easily be obtained at a local store and since it is part of the population of all M&M'S®, it can help us draw conclusions about the proportion of green M&M'S® in all milk chocolate M&M'S® produced by Mars, Inc.

**STEP 2:** Answer the following questions before using the samples of M&M'S® in your investigation.

1. What are we interested in finding out about each of the samples of M&M'S®?
   Answer: The statistical question set up by students in Step 1, #1, involved the proportion of all milk chocolate M&M'S® produced by Mars, Inc. that are green. After referring back to this question, students should conclude that they are interested in finding out about the proportion of green M&M'S® in each sample.

2. What information do we need in order to answer our question or investigate the claim that 16% of milk chocolate M&M'S® produced by Mars, Inc. are green? How can we use the samples of M&M'S® to obtain this information?
   Answer: Students are again asked to recognize that they need the proportion of green M&M'S® in the population of all milk chocolate M&M'S® produced by Mars, Inc.

They should then use the background information at the beginning of the activity sheet to help them conclude that they can use the samples of M&M'S® as samples from which they can collect information about the population of all M&M'S®.

**STEP 3:** Each pair or group of students will perform the following investigation using **one** sample of M&M'S®.

The total number of M&M'S® in one sample is 30.

1. Calculate the proportion of green M&M'S® in the sample.

   Proportion of green M&M'S® _____
   Answer: Answers will vary. It is recommended that the teacher know the proportion of green M&M'S® in the bucket from which students are drawing samples so he/she can know if students' results are reasonable and can have an idea of the needed range on the dot plot created in (3).

2. Give an estimate for the proportion of green M&M'S® that Mars, Inc. makes based on your sample.
   Answer: Answers will vary, but should correspond with the answer obtained on the previous question.

3. Write the proportion you found in (1) on the sticky note you were given and place it in the appropriate position on the dot plot your teacher has drawn on the board. Did every sample have the same proportion of green M&M'S®?
   Answer: Student answers should be checked in order to determine the range needed for the class dot plot. The horizontal axis on the dot plot should be scaled so students can easily determine where to place their sticky note. Students should quickly see that every sample did not have the same proportion of green M&M'S®.

4. What value is at the center of the dot plot constructed by using one sample per group? Is it a coincidence that the value is close to/far from the 16% claimed by Mars, Incorporated?
   Answer: The value at the center of the dot plot should be close to the proportion of green M&M'S® in the bucket from which the samples were drawn. The students should conclude that it is not a coincidence that the value is close to/far from the 16% claimed by Mars, Inc. If the value is close to 16%, students should mention that this would occur because the samples are a part of the population of all M&M'S® produced by Mars, Inc. and this is evidence that the claim is true. If the value is far from 16%, students should conclude that there could be variation in the proportion of green M&M'S® from sample to sample or that the claim could possibly not be true.

5. Mars, Inc. claimed that 16% of milk chocolate M&M'S® produced are green. Does the information on the dot plot seem to support this claim? Why or why not?
   Answer: If the value at the center of the dot plot is close to 16%, then students should indicate that the dot plot seems to support the claim. They should explain that since the value at the center is close to 16%, the average value of the proportions of green M&M'S® is close to 16%. If the value at the center of the dot plot is far away from 16%, then students should indicate that the dot plot does not support the claim because the average value of the proportion of green M&M'S® does not seem to be 16%.

6. Define each of the following **in the context of the investigation** you are performing with one sample of M&M'S®.

   Population of interest _____
   Answer: All milk chocolate M&M'S® produced by Mars, Inc. See explanation in answer to Step 1, #3.

   Population parameter of interest_____
   Answer: Proportion of green M&M'S® in the population of all milk chocolate M&M'S® produced by Mars, Inc. See explanation in answer to Step 1, #4.

   Sample (drawn from population of interest) _____
   Answer: 30 milk chocolate M&M'S® from the bucket. Students should be very specific in their answer, indicating the number of M&M'S® in the sample and where the sample was obtained.

   Statistic (used to estimate population parameter of interest) _____
   Answer: Proportion of green M&M'S® in one sample of milk chocolate M&M'S® from the bucket. It is important that students indicate that it is the proportion in ONE sample and where the sample was obtained.

**STEP 4:** Each pair or group of students will perform the following investigation using two samples of M&M'S®.

The total number of M&M'S® in two samples is 60.

1. Calculate the proportion of green M&M'S® in the overall sample (two samples with 30 M&M'S® in each sample).

   Proportion of green M&M'S® in two samples _____
   Answer: Answers will vary, but should be reasonable considering the proportion of green M&M'S® in the bucket from which the sample was drawn.

2. Give an estimate for the proportion of green M&M'S® that Mars, Inc. makes based on your overall sample.
   Answer: Answers will vary, but should correspond with the answer obtained on the previous question.

3. Write the proportion you found in (1) on the sticky note you were given and place it in the appropriate position on the dot plot your teacher has drawn on the board. Did every group have the same proportion of green M&M'S® in two samples?
   Answer: Student answers should be checked in order to determine the range needed for the class dot plot. The horizontal axis on the dot plot should be scaled so students can easily determine where to place their sticky note. Students should quickly see that every group did not have the same proportion of green M&M'S® in two samples.

4. What value is at the center of the dot plot constructed by using the overall samples of each group? Is it a coincidence that the value is close to/far from the 16% claimed by Mars, Inc.?
   Answer: The value at the center of the dot plot should be close to the proportion of green M&M'S® in the bucket from which the samples were drawn. The students should conclude that it is not a coincidence that the value is close to/far from the 16% claimed by Mars, Inc. If the value is close to 16%, students should mention that this would occur because the samples are a part of the population of all M&M'S® produced by Mars, Inc. and this is evidence that the claim is true. If the value is far from 16%, students should conclude that there could be variation in the proportion of green M&M'S® from sample to sample or that the claim could possibly not be true.

5. Mars, Inc. claimed that 16% of milk chocolate M&M'S® produced are green. Does the information on the dot plot for two samples seem to support this claim more or less than the information obtained from one sample? Why or why not?
   Answer: Students should observe that the spread of the distribution of sample proportions for sample size $n = 60$ is less than the spread for $n = 30$. Therefore, there is less variability in the sample proportions for size $n = 60$. For this reason students should conclude that the dot plot for two samples does seem to support the claim more than the information obtained from one sample.

6. Define each of the following **in the context of the investigation** with two samples of M&M'S®.

   Population of interest _____
   Answer: All milk chocolate M&M'S® produced by Mars, Inc. See explanation in answer to Step 1, #3.

Population parameter of interest_____
Answer: Proportion of green M&M'S® in the population of all milk chocolate M&M'S® produced by Mars, Inc. See explanation in answer to Step 1, #4.

Sample (drawn from population of interest) _____
Answer: Two samples of size 30 of milk chocolate M&M'S® from the bucket. Students should be very specific in their answer, indicating the number of M&M'S® in the sample and where the sample was obtained.

Statistic (used to estimate population parameter of interest) _____
Answer: Proportion of green M&M'S® in two samples of milk chocolate M&M'S® from the bucket. It is important that students indicate that it is the proportion in two samples (total of 60 M&M'S®) and where the sample was obtained.

7. What type of changes occurred in the dot plot when you used two samples of M&M'S® instead of one?
   Answer: Students should observe that the spread of the distribution decreased when the sample size increased.

8. If you only had one sample on which to base your estimate, how far off might your estimate be? What would the worst case scenario be with one sample shown on the dot plot? What would the worst case scenario be if you had two samples shown on the dot plot?
   Answer: For the data on the sample dot plot created on pages 3-4 of this lesson, students may find a sample proportion as small as .03 or as high as .27 for $n = 30$. The worst case scenario for $n = 60$ will be .10 on the low end and .25 on the high end. Students should recognize that the spread is decreasing as the $n$ increases. Students will give similar answers based on the class dot plots for sample sizes $n = 30$ and $n = 60$.

**Assessment**

1. Explain the difference between a population parameter and a sample statistic.

2. There are six different colors of milk chocolate M&M'S® produced by Mars, Incorporated. The company claims that the proportion of each color in the total population of M&M'S® has not changed over time. Suppose you bought a bag of M&M'S® produced by Mars Incorporated and found that 12% of the bag was a certain specified color. Describe an activity that would allow you to estimate how far away your estimate of 12% might be from the population proportion of that color M&M®.

**Answers**

1. A statistic is a numerical summary computed from a sample. A parameter is a numerical summary computed from a population. A population parameter is a constant value that does not change, whereas a statistic will vary depending on the sample from which it was calculated.

2. Answers will vary. Essential elements in the description would be:
   a. A random sampling method using M&M'S® as originally packaged.
   b. Sample sizes that are large enough to be representative of the total population of M&M'S®.
   c. A sampling method that involves obtaining repeated samples of the same size.
   d. A method of representing the sampling distribution of the proportion of the specified color of M&M'S®, such as a dot plot or histogram.
   e. Directions for performing an informal analysis of the sampling distribution displayed in the dot plot or histogram.

**Possible Extensions**

1. After students understand the basic concept of a sampling distribution, they design activities with colored chips or decks of cards in which they develop a dot plot of the sampling distribution and describe the shape, center, spread and outliers.

2. Students are introduced to the concept of the variability of a statistic and its relationship to the spread of its sampling distribution. This is extended further as students are introduced to the concept that larger samples give smaller spreads. This can lead to the discussion of the fact that the size of the population does not affect the spread of the sampling distribution as long as the population is at least 10 times larger than the sample.

**References**

1. *Guidelines for Assessment and Instruction in Statistics Education* (GAISE) *Report,* ASA, Franklin et al., ASA, 2007 http://www.amstat.org/education/gaise/.

2. *The Practice of Statistics*, Fourth Edition by Starnes, Daren S., Yates, Daniel S., and Moore, David S., 2012. W.H. Freeman and Company.

**Population Parameters with M&M'S® Activity Sheet**

**Background:**
A **population parameter** is a number that describes some characteristic of a given **population**. In statistics, the population is the entire group of individuals about which we want information. The population parameter is a constant value that does not change. Many times it is impractical or even impossible to calculate the population parameter of interest, the most common reason being that populations are often composed of very large numbers of individuals. When we cannot calculate the population parameter directly, we use a **sample**, which is a part of the population from which we actually collect information**.** From the sample we calculate a **statistic**, which is a number that describes some characteristic of the sample. A statistic will vary depending on the sample from which it was calculated.

How are the **sample** and the **population** related? We use information from a **sample (a statistic)** to draw conclusions about a **population parameter**. We will use this relationship while performing the following investigation.

**Claim:**
Mars, Incorporated claims that when producing milk chocolate M&M'S®, 16% of the total number produced is green in color.

**Question of Interest:**
**Is the claim that 16% of milk chocolate M&M'S® produced by Mars, Inc. are green a valid claim?**

**Instructions:** Your class will be divided into pairs or small groups to perform the following investigation in order to answer the question above.

**STEP 1:** Preliminary questions.

1. What is the specific question(s) that needs to be addressed in your investigation?

2. How does this question relate to the background information at the beginning of the activity? Be sure to use some of the bold-faced terms in your answer.

3. What is the population of interest in the investigation?

4. What is the population parameter of interest in the investigation?

5. Why can we not realistically calculate the population parameter of interest directly?

6. How could the concept of random sampling be used to investigate the population parameter of interest?

**Your group will now be presented with a large classroom bin full of M&M'S®. Teachers should ensure there are at least 500 M&M'S® in the bucket. Groups will then come up to the bucket one-by-one and, without looking, grab 30 M&M'S®. The group will make note of the number of M&M'S® of each color, place the sampled M&M'S® back in the bucket, and repeat the process. Once two samples are recorded, the group will return to their seats to answer the questions in Steps 2 through 4.**

**STEP 2:** Answer the following questions before using the samples of M&M'S® in your investigation.

1. What are we interested in finding out about each of the samples of M&M'S®?

2. What information do we need in order to answer our question or investigate the claim that 16% of milk chocolate M&M'S® produced by Mars, Inc. are green? How can we use the samples of M&M'S® to obtain this information?

**STEP 3:** Each pair or group of students will perform the following investigation using **one** sample of M&M'S®.

The total number of M&M'S® in one sample is 30.

1. Calculate the proportion of green M&M'S® in the sample.

   Proportion of green M&M'S® _____

2. Give an estimate for the proportion of green M&M'S® that Mars, Inc. makes based on your sample.

3. Write the proportion you found in (1) on the sticky note you were given and place it in the appropriate position on the dot plot your teacher has drawn on the board. Did every sample have the same proportion of green M&M'S®?

4. What value is at the center of the dot plot constructed by using one sample per group? Is it a coincidence that the value is close to/far from the 16% claimed by Mars, Incorporated?

5. Mars, Inc. claimed that 16% of milk chocolate M&M'S® produced are green. Does the information on the dot plot seem to support this claim? Why or why not?

6. Define each of the following **in the context of the investigation** you are performing with one sample of M&M'S®.

   Population of interest _____

   Population parameter of interest_____

   Sample (drawn from population of interest) _____

   _____

   Statistic (used to estimate population parameter of interest) _____

   _____

**STEP 4:** Each pair or group of students will perform the following investigation using two samples of M&M'S®.

The total number of M&M'S® in two samples is 60.

1. Calculate the proportion of green M&M'S® in the overall sample (two samples with 30 M&M'S® in each sample).

   Proportion of green M&M'S® in two samples _____

2. Give an estimate for the proportion of green M&M'S® that Mars, Inc. makes based on your overall sample.

3. Write the proportion you found in (1) on the sticky note you were given and place it in the appropriate position on the dot plot your teacher has drawn on the board. Did every group have the same proportion of green M&M'S® in two samples?

4. What value is at the center of the dot plot constructed by using the overall samples of each group? Is it a coincidence that the value is close to/far from the 16% claimed by Mars, Inc.?

5. Mars, Inc. claimed that 16% of milk chocolate M&M'S® produced are green. Does the information on the dot plot for two samples seem to support this claim more or less than the information obtained from one sample? Why or why not?

6. Define each of the following **in the context of the investigation** with two samples of M&M'S®.

   Population of interest _____

   Population parameter of interest_____

   Sample (drawn from population of interest) _____

   _____

   Statistic (used to estimate population parameter of interest) _____

   _____

7. What type of changes occurred in the dot plot when you used two samples of M&M'S® instead of one?

8. If you only had one sample on which to base your estimate, how far off might your estimate be? What would the worst case scenario be with one sample shown on the dot plot? What would the worst case scenario be if you had two samples shown on the dot plot?

**Answers to Activity Sheet**

**STEP 1:**

1. What proportion of all milk chocolate M&M'S® produced by Mars, Inc. are green?
2. We want to know a population parameter, which is the proportion of green M&M'S®. The population of interest is the total population of all milk chocolate M&M'S® produced by Mars, Inc.
3. All milk chocolate M&M'S® produced by Mars, Inc.
4. The proportion of green M&M'S®.
5. It would be impossible to count all M&M'S® produced by Mars, Inc. because there would be too many, and production is an ongoing process.
6. We could use a sample of M&M'S® that could reasonably be obtained at a local store and easily be counted. We would use information from the sample to draw conclusions about the proportion of green M&M'S® in all milk chocolate M&M'S® since the sample is a part of this population.

**STEP 2:**

1. The proportion of green M&M'S®.
2. We need the proportion of green M&M'S® in the population of all milk chocolate M&M'S® produced by Mars, Inc. We can use the samples of M&M'S® as samples from which we can collect information about the population.

**STEP 3:**

1. Answers will vary.
2. Answers will vary.
3. No, every sample did not have the same proportion of green M&M'S®.
4. Answers will vary, but should be approximately 16%. No, this is not a coincidence.
5. The information on the dot plot should support the claim. The value at the center of the dot plot is approximately 16%.
6. Population of interest – all milk chocolate M&M'S® produced by Mars, Inc.
   Population parameter of interest – proportion of green M&M'S® in the population of all milk chocolate M&M'S® produced by Mars, Inc.
   Sample – 30 milk chocolate M&M'S® from the bucket
   Statistic – proportion of green M&M'S® in one sample of milk chocolate M&M'S® from the bucket

**STEP 4:**

1. Answers will vary.
2. Answers will vary.
3. No, every sample did not have the same proportion of green M&M'S®.
4. Answers will vary, but should be approximately 16%. No, this is not a coincidence.
5. The information on the dot plot for two samples seems to support this claim more than the information obtained from one package. Students should observe that the spread of the distribution of sample proportions for sample size $n = 60$ is less than the spread for $n = 30$. Therefore, there is less variability in the sample proportions for size $n = 60$. For this reason students should conclude that the information on the dot plot for two samples seems to support the claim more than the information obtained from one sample.
6. Population of interest – all milk chocolate M&M'S® produced by Mars, Inc.
   Population parameter of interest – proportion of green M&M'S® in the population of all milk chocolate M&M'S® produced by Mars, Inc.
   Sample – two samples of size 30 of milk chocolate M&M'S®
   Statistic – proportion of green M&M'S® in 60 milk chocolate M&M'S® from the bucket.
7. The spread of the distribution decreased.
8. For the data on the sample dot plot created on page 4 of this lesson, students may find a sample proportion as small as .03 or as high as .27 for $n = 30$. The worst case scenario for $n = 60$ will be .10 on the low end and .25 on the high end. Students should recognize that the spread is decreasing as the $n$ increases. Students will give similar answers based on the class dot plots for sample sizes $n = 30$ and $n = 60$.