

## Formative Assessments by Learning Goal

### MAFS.912.S-ID.3.9

#### Distinguish between correlation and causation.

**\*Note: Be sure to remind students that strict causality is rare and many times there is more than one cause for a given effect.**

#### Learning Goal 1:

Students will be able to differentiate between the definition/consequences of correlation and causation. (Correlation is *necessary* but not *sufficient* for causation)

- Formative: Use the following correlations and a method (such as clickers, whiteboards, show of hands, etc...) to assess students' ability in determining if there is a causal relationship:
  1. There is a positive correlation between age and income.
    - *Not causal. Students should identify that just because you are older does not mean you are going to make more money.*
  2. There is a positive correlation between house size and the value of the house.
    - *Possibly causal. Students should identify that there are other contributing causes include location, age, condition, etc.*
  3. There is a negative correlation between the distance driven and amount of gas in the tank.
    - *Probably causal. Students should note that there are not many other factors (besides there being a hole in your gas tank) that could lead to a decrease in the amount of gas in your tank. In other words, more driving causes the car to use more gas.*

#### Learning Goal 2:

Students will be able to identify different causal fallacies (common cause, reverse causation, oversimplified cause, bidirectional causation and coincidence) and apply their knowledge to real-world situations (news articles, scientific studies, peer conclusions, etc...).

- Formative: Use the following correlations and a method (such as clickers, whiteboards, show of hands, etc...) to assess students' ability in determining if there is a fallacy in assuming a causal relationship and if so which one:
  1. You notice that students with a tutor have lower than average GPAs. So tutors must cause bad grades. (*Fallacy: Reversing cause and effect*)
    - *Students should realize that tutoring does not cause lower grades, but lower grades is a cause for being tutored.*
  2. You notice that the more sunscreen that is purchased, the higher the crime rate. So using sunscreen causes people to commit crimes. (*Fallacy: Common cause*)
    - *Students should identify that the use of sunscreen does not cause people to commit crimes, but both crime and sunscreen use increase with warmer weather.*

These assessments are to be used after the instruction of each learning goal (during the lesson).

3. You notice that the less money people make, the more often they are sick. So being poor causes illness. *(Fallacy: Oversimplification)*
  - Students should notice that there are many factors that contribute to both illness. Low income may contribute lower quality health care, decreased living conditions and less access to medications. These factors may, in conjunction, lead to higher incidence of illness.
4. You notice that the more your friend likes a class, the better grade s/he earns. So liking a class causes him/her to get better grades. *(Fallacy: Bidirectional causation)*
  - Students may assert causation (which is a valid assertion), but should also notice that causation would go in both directions. The more a student likes a class may be a cause for higher grades, but in turn better performance in a class may cause a student to like the class more.
5. You notice that the taller your friend is the higher his/her IQ. So increased height causes increased IQ. *(Fallacy: Coincidence)*
  - Students should acknowledge that there is no obvious logical reason that the height of a person would affect the person's intelligence.

**Learning Goal 3:**

Students will be able to determine (using the correlation coefficient and randomized experiments) if the relationship within bivariate data is correlated, causal or both.

- **Formative:** Given the following data, students will calculate (using technology) the correlation coefficient and determine if the data is correlated, causal or both. Students should identify that a high correlation may support, but cannot prove a causal relationship. Students should note that because the observations were held in a controlled setting (all other factors such as time of day were held constant) the high correlation coefficient strongly supports a causal relationship.

**\*NOTE:** Observations were taken in a controlled setting

Cricket Chirps (15s)	Temperature
20	88.6
16	71.6
19.8	93.3
18.4	84.3
17.1	80.6
15.5	75.2
14.7	69.7
17.1	82
15.4	69.4
16.2	83.3

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15	78.6
17.2	82.6
16	80.6
17	83.5
14.1	76.3

**Correlation Coefficient = 0.84**

The teacher should, at the conclusion of this analysis, mention that the physical behavior of crickets, being cold-blooded, is in fact affected by the temperature of its environment.

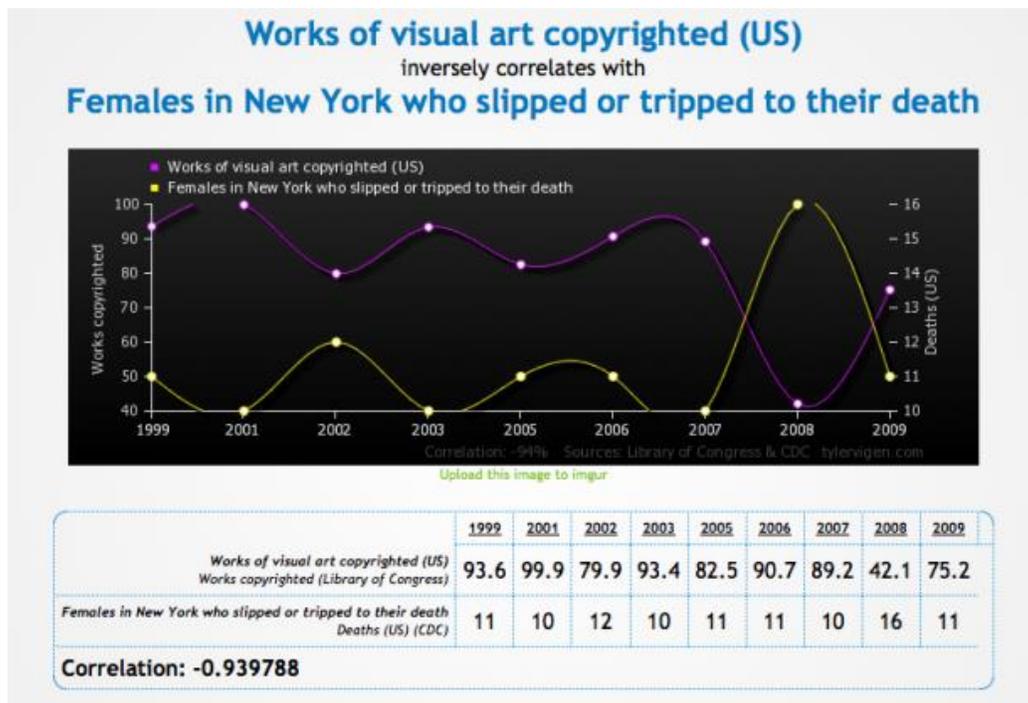
#### **Learning Goal 4:**

Students will understand how assuming causation can lead to erroneous conclusions.

In the following assessment, one graph/data table should be assigned to each group. The groups will then discuss and share erroneous conclusions that can be made when a causal relationship is assumed solely on the bases of high correlation.

- Formative: Use the following correlations and have students discuss in a small group setting why assuming a cause and effect relationship for each does not make logical sense.

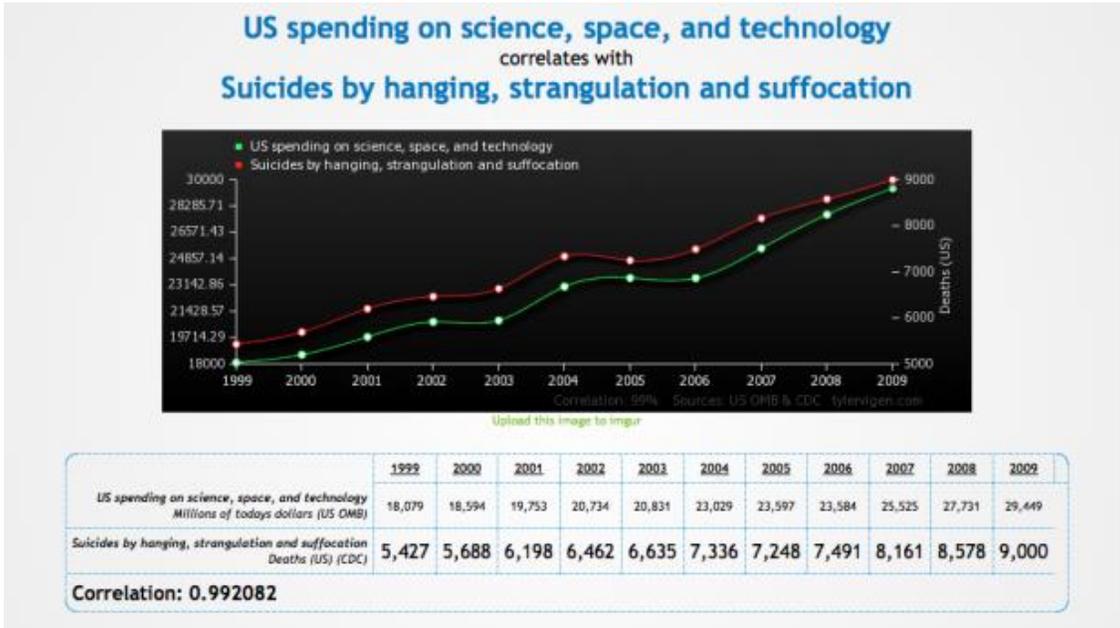
1. According to the Library of Congress and the Center for Disease Control, the number of visual art works and the number of females who tripped to their deaths were inversely linked with a correlation coefficient of -0.94.



These assessments are to be used after the instruction of each learning goal (during the lesson).

- *Erroneous Conclusion: The copyrighting of visual art keeps women from dying due to tripping.*

2. According to the United States Office of Management and Budget (OMB) and the Center for Disease Control (CDC), US spending on science, space and technology is linked to the number of suicides by hanging, strangulation and suffocation with a correlation coefficient of 0.99

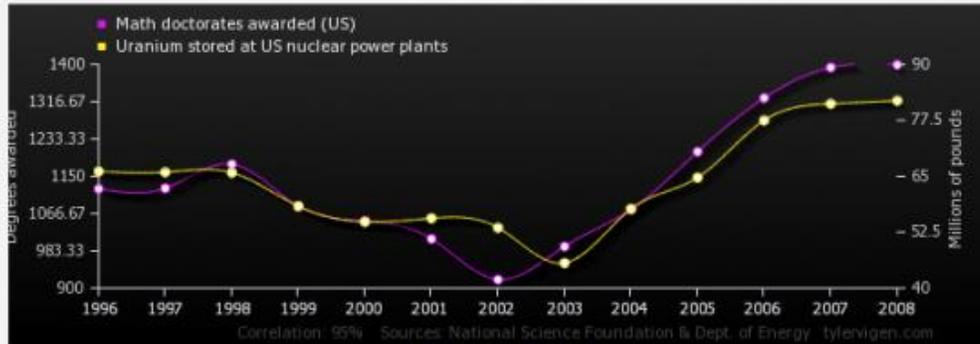


- *Erroneous Conclusion: Studying science causes people to hang themselves.*

3. According to the National Science Foundation (NSF) and United States Department of Energy (DOE) the number of Ph.D.'s in mathematics and the amount of uranium stored at US nuclear power plants are linked with a correlation coefficient of 0.95.

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## Math doctorates awarded (US) correlates with Uranium stored at US nuclear power plants



	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
<i>Math doctorates awarded (US)</i> Degrees awarded (National Science Foundation)	1,122	1,123	1,177	1,083	1,050	1,010	919	993	1,076	1,205	1,325	1,393	1,399
<i>Uranium stored at US nuclear power plants</i> Millions of pounds (Dept. of Energy)	66.1	65.9	65.8	58.3	54.8	55.6	53.5	45.6	57.7	64.7	77.5	81.2	81.9

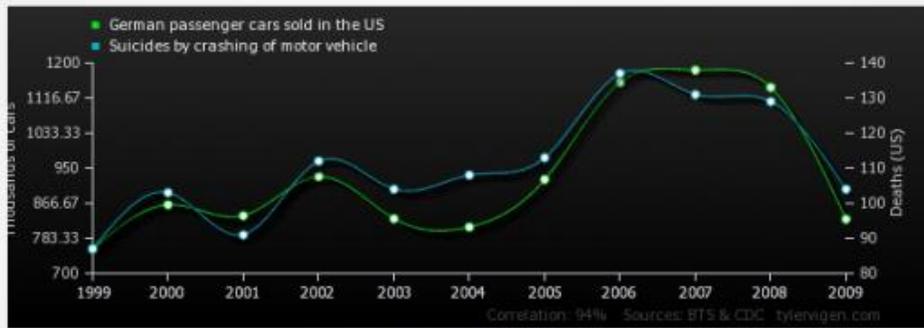
**Correlation: 0.952257**

- *Erroneous Conclusion: Mathematicians are hoarding uranium at power plants.*

4. According to the Bureau of Transportation Statistics (BTS) and the Center for Disease Control, the number of German passenger cars sold in the US and the number suicides by the crashing of motor vehicle is linked with a correlation coefficient of 0.94.

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## German passenger cars sold in the US correlates with Suicides by crashing of motor vehicle



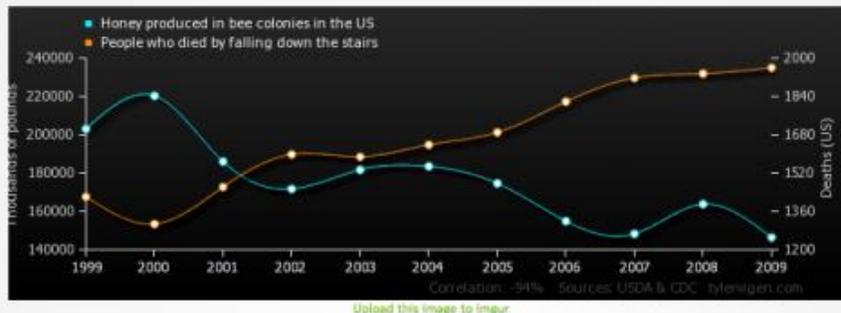
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
German passenger cars sold in the US Thousands of cars (BTS)	758	863	837	930	830	810	923	1,154	1,183	1,142	829
Suicides by crashing of motor vehicle Deaths (US) (CDC)	87	103	91	112	104	108	113	137	131	129	104

**Correlation: 0.935701**

- *Erroneous Conclusion: German cars influence people to crash them and kill themselves.*

5. According to the Department of Agriculture and Center for Disease Control, the amount of honey produced and the number of people who died by falling down the stairs are inversely related with a correlation coefficient of -0.94.

## Honey produced in bee colonies in the US inversely correlates with People who died by falling down the stairs



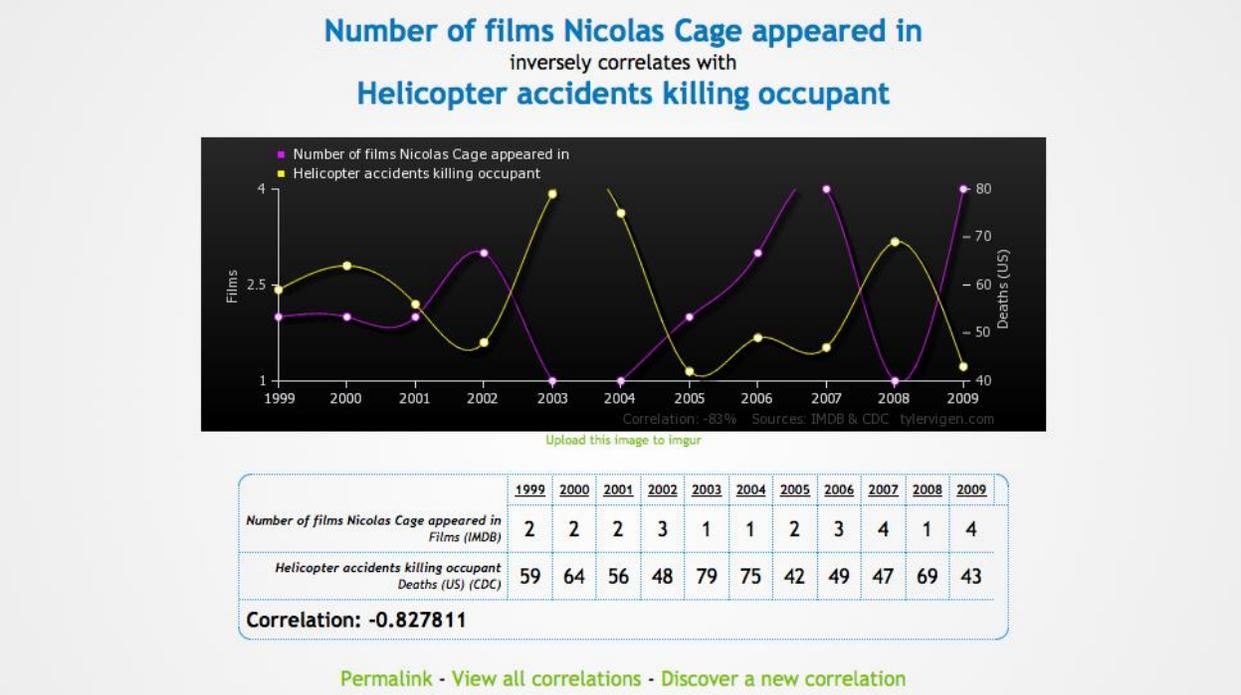
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Honey produced in bee colonies in the US Thousands of pounds (USDA)	203,068	220,286	186,051	171,718	181,724	183,494	174,614	154,910	148,341	163,789	146,416
People who died by falling down the stairs Deaths (US) (CDC)	1,421	1,307	1,462	1,598	1,588	1,638	1,690	1,818	1,917	1,935	1,960

**Correlation: -0.941282**

These assessments are to be used after the instruction of each learning goal (during the lesson).

- *Erroneous Conclusion: Decreased honey production distracts people causing them to fall down stairs to their death.*

6. According to IMDB and the Center for Disease Control, the number of movies Nicholas Cage appeared in and the number of helicopter accidents killing the occupant are inversely related with a correlation coefficient of -0.83.



- *Erroneous Conclusion: Nicholas Cage movies prevents helicopter crashes*

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