Observing More Patterns in Scatter Plots

Goals

- Categorize data sets, and describe (orally) the properties used to create categories.
- Describe (orally) features of data on scatter plots, including "linear" and "non-linear association" and "clustering," using informal language.
- Explain (orally) what might cause a non-linear association or clustering of data points in context.

Learning Targets

- I can pick out clusters in data from a scatter plot.
- I can use a scatter plot to decide if two variables have a linear association.

Lesson Narrative

In this lesson, students see non-linear associations for the first time and use a card sort to distinguish linear and non-linear associations. They visually identify clusters in data and explain that this may be caused by subgroups within a data set exhibiting different trends. At this level, students rely on the structure of visual patterns in scatter plots to recognize non-linear associations and clustering rather than quantitative tools.

Student Learning Goal

Let's look for other patterns in data.

Access for Students with Diverse Abilities

- Engagement (Activity 1, Activity 2)

Access for Multilingual Learners

- MLR2: Collect and Display (Activity 2)

Instructional Routines

- MLR2: Collect and Display
- Notice and Wonder
- Take Turns

Required Materials

Materials to Gather
- Pre-printed cards, cut from copies of the blackline master: Activity 1

Materials to Copy
- Scatterplot City Cards (1 copy for every 1 students): Activity 1

Required Preparation

Lesson:
Print and cut up cards from the "Scatter Plot City" blackline master. Prepare 1 set of cards for every student.

Lesson Timeline

5 min Warm-up	**20** min Activity 1	**10** min Activity 2	**10** min Lesson Synthesis	**5** min Cool-down

Assessment

Inspire Math

Old Faithful video

Go Online

Before the lesson, show this video to **reinforce** the real-world connection.

ilclass.com/l/614214
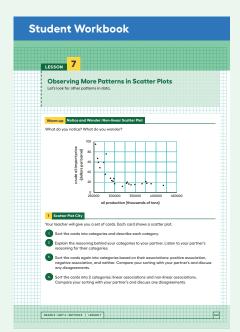
Please log in to the site before using the QR code or URL.

Instructional Routines

Notice and Wonder

ilclass.com/r/10694948

Please log in to the site before using the QR code or URL.

Student Workbook

Warm-up

Notice and Wonder: Non-linear Scatter Plot

5 min

Activity Narrative

The purpose of this *Warm-up* is to elicit the idea that some variables can be associated in a way that is not linear, which will be useful when students work with non-linear data in a later activity. While students may notice and wonder many things about these data, the association and non-linearity are the important discussion points.

When students articulate what they notice and wonder, they have an opportunity to attend to precision in the language they use to describe what they see. They might first propose less formal or imprecise language, and then restate their observation with more precise language in order to communicate more clearly.
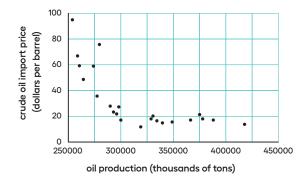
Launch 👥

Arrange students in groups of 2. Display the scatter plot for all to see. Tell students that oil production and price are shown. Production is measured in "thousands of tons," so a point on the left side of this graph represents 250,000 thousand tons (or 250,000,000 tons). Price is measured in "dollars per barrel." One barrel of oil is equivalent to 42 gallons. The prices in this chart are for crude oil which would still need to be processed to be made useful for gasoline, plastics, or other oil-based materials.

Ask students to think of at least one thing they notice and at least one thing they wonder. Give students 1 minute of quiet think time, and then 1 minute to discuss the things they notice and wonder with their partner.

Student Task Statement

What do you notice? What do you wonder?

Things students may notice:

- The points don't all lie near a line like they have in previous scatter plots.
- As production increases, the price decreases.

Things students may wonder:

- What does "oil production" or "import price" mean?
- Is it okay to model this relationship using a line?
- Why does it seem to level out at the end?

Activity Synthesis

Ask students to share the things they noticed and wondered. Record and display their responses without editing or commentary for all to see. If possible, record the relevant reasoning on or near the scatter plot. Next, ask students,

💬 *"Is there anything on this list that you are wondering about now?"*

Encourage students to observe what is on display and respectfully ask for clarification, point out contradicting information, or voice any disagreement.

If the idea that the data show an association, but are not linear does not come up during the conversation, ask students to discuss this idea.

Tell students that, even when a linear association seems to be present, it may only fit the data very close to the data that is present. For example, if we cover up the scatter plot to the right of 300,000 thousand tons, there may appear to be a linear association that would fit the data, but it would not apply to the data on the right side of the scatter plot. Additionally, in this particular situation, a linear model does not make sense in the long term, since a linear model would eventually have a value of 0 and then become negative, something that would probably not happen to the price of oil.

Activity 1
Scatter Plot City

20 min

Activity Narrative

In this activity, students individually sort cards of different scatter plots then discuss with a partner. Students sort different scatter plots during this activity. A sorting task gives students opportunities to analyze representations, statements, and structures closely and make connections.

Launch 👥

Arrange students in groups of 2 and distribute pre-cut cards. Tell them that in this activity, they will sort some cards into categories of their choosing. When they sort the scatter plots, they should work with their partner to come up with categories.
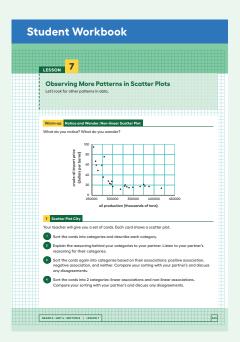
Access for Students with Diverse Abilities (Activity 1, Student Task)

Engagement: Develop Effort and Persistence.
Chunk this task into more manageable parts. Give students a subset of the cards to start with and introduce the remaining cards once students have completed their initial set of matches.

Supports accessibility for: Conceptual Processing, Organization, Memory

Student Workbook

Student Task Statement

Your teacher will give you a set of cards. Each card shows a scatter plot.

1. Sort the cards into categories and describe each category.

   Sample categories: decimals and whole numbers, positive and negative associations, more and less variable

2. Explain the reasoning behind your categories to your partner. Listen to your partner's reasoning for their categories.

   No response necessary

3. Sort the cards again into categories based on their associations: positive association, negative association, and neither. Compare your sorting with your partner's and discuss any disagreements.

   - Positive associations: F and G
   - Negative associations: B, C, D, and E
   - Neither: A and H

4. Sort the cards into 2 categories: linear associations and non-linear associations. Compare your sorting with your partner's and discuss any disagreements.

   Linear associations: C and E. Non-linear associations: A, B, D, F, G, and H

Activity Synthesis

Select groups to share their initial categories and how they sorted their scatter plots into the given categories. Attend to the language that students use to describe their categories and scatter plots, giving them opportunities to describe their scatter plots more precisely. Highlight the use of terms like "linear," "non-linear," and "positive or negative association."
To help clarify the meaning of non-linear association, consider asking:

💬 *"How did you determine if an association is non-linear?"*

   if the data looks like it's curving or not in a line

💬 *"Can a non-linear association show a positive association? What might that look like in a scatter plot?"*

   Yes, the scatter plot on card F is an example.

💬 *"If a scatter plot has no association at all (neither linear nor non-linear), what might its scatter plot look like?"*

   a lot of random dots scattered all around the plot with no obvious trend

Activity 2
Clustering

10 min

Activity Narrative

In addition to the type of model appropriate for the data represented in a scatter plot and the positive or negative association, there are other patterns that can be worth noticing before performing a more in-depth analysis. In this activity, students compare scatter plots that have more than one pattern embedded in them. In the discussion following the activity, this feature is identified as *clustering*.

As students compare the scatter plots in this activity, monitor for students who notice clustering of the data and name it in their own words.

Launch 👥
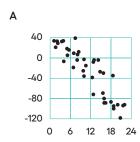
Keep students in groups of 2. Allow 2 minutes quiet think time followed by partner and whole-class discussion.
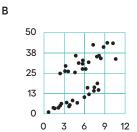
Use *Collect and Display* to create a shared reference that captures students' developing mathematical language. Collect the language students use to describe the scatter plots. Display words and phrases such as "groups," "subgroups," "clusters," "trends," and "associations."
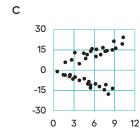
Student Task Statement
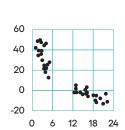
Find groups of 2 or 3 scatter plots that share something in common that the others do not. What do they have in common?

Sample responses:

- Plots A and D both have negative associations.
- Plots B and C both have 2 groups of data that would have different lines of fit.
- Plots A, C, and D each have data in Quadrants I and IV, but Plot B only has data in Quadrant I.
- Plots B, C, and D appear to have subgroups that go together.

Activity Synthesis

The purpose of this discussion is for students to understand what it means for data to appear in clusters and recognize when they might appear.

Direct students' attention to the reference created using *Collect and Display*. Ask previously identified students to share their observations about the scatter plots. Invite students to borrow language from the display as needed and update the reference to include additional phrases as they respond.

Tell students that when data seems to have more than one pattern, it is called "clustering." Clustering of the data like in graphs B, C, and D can reveal hidden patterns. Usually, clustering means there are subgroups within our data that may represent different trends.

For example, in Plot B, the data may represent body measurements of a certain species of bird. Although the data originally came from a group that made sense (a single species), there appear to be subgroups that have a large influence on the data as well. The lower half of the data may represent females and the upper half may represent males, so we can see that there are different patterns within the different subgroups.

When clustering is present, it may be helpful to investigate the cause of the separation and analyze the data within the subgroups rather than as a whole.

Lesson Synthesis

To help summarize the lesson, ask:

💬 *"In your own words, what is a non-linear association?"*

The points in a scatter plot do not lie along a straight line.

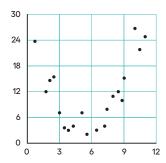💬 *"What does a non-linear association mean?"*

There is not a constant increase or decrease of one variable based on the other.

💬 *"In your own words, what are clusters in data?"*

The points in a scatter plot are clumped together in different groups.

💬 *"What do clusters usually mean?"*

There may be multiple patterns present within the data. Perhaps there are subgroups that show different patterns.
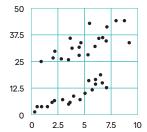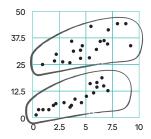
Lesson Summary

Sometimes a scatter plot shows an association that is not linear:
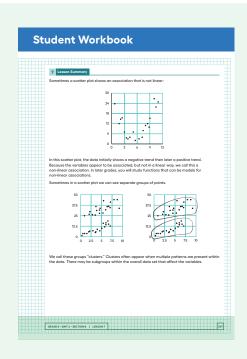

In this scatter plot, the data initially shows a negative trend then later a positive trend. Because the variables appear to be associated, but not in a linear way, we call this a *non-linear association*. In later grades, you will study functions that can be models for non-linear associations.

Sometimes in a scatter plot we can see separate groups of points.

We call these groups "clusters." Clusters often appear when multiple patterns are present within the data. There may be subgroups within the overall data set that affect the variables.

Cool-down

Make Your Own Scatter Plot

5 min

Students show their understanding of positive and negative association, linear and non-linear association, and clustering of data by drawing scatter plots with these conditions.
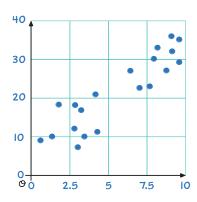
Launch

Advise students to use around 20 data points in their graph. This is enough to show the intention of the graph without being tedious.
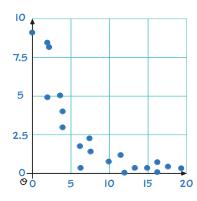
Student Task Statement

1. Draw a scatter plot that shows a positive linear association and clustering.

   Sample response:

2. Draw a scatter plot that shows a negative non-linear association and no clustering.
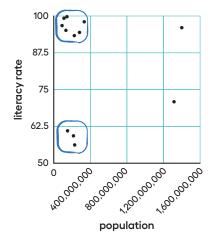
   Sample response:
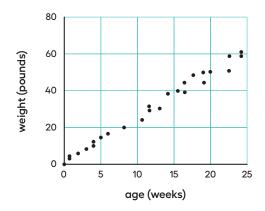
Practice Problems

5 Problems

Problem 1

Literacy rate and population for the 12 countries with more than 100 million people are shown in the scatter plot. Circle any clusters in the data.
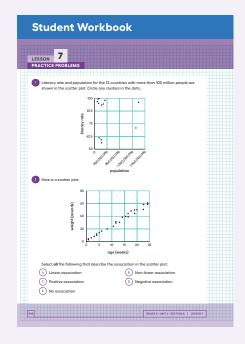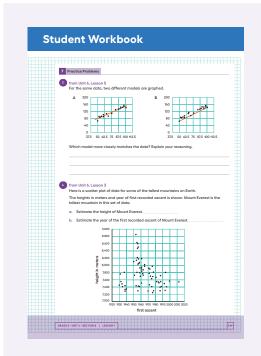

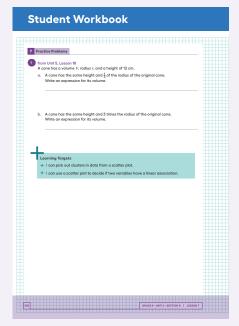### Problem 2

Here is a scatter plot:

Select **all** the following that describe the association in the scatter plot:

A. Linear association

B. Non-linear association

C. Positive association
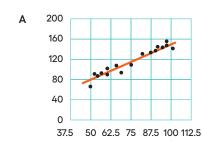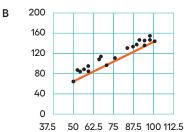
D. Negative association

E. No association

Student Workbook

Student Workbook

For the same data, two different models are graphed. Which model more closely matches the data? Explain your reasoning.
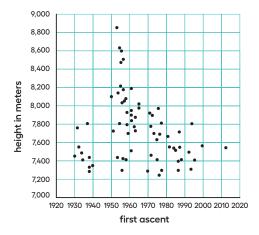

Sample response: Model A more closely matches the data. In Model B, most of the points are above the line in the graph. In Model A, the points are more evenly arranged around the line.

Here is a scatter plot of data for some of the tallest mountains on Earth.

The heights in meters and year of first recorded ascent is shown. Mount Everest is the tallest mountain in this set of data.

a. Estimate the height of Mount Everest.

Approximately 8,848 meters, because the vertical coordinate of the data point with the greatest vertical value is closer to 8800 than 9000

b. Estimate the year of the first recorded ascent of Mount Everest.

Approximately 1953, because the horizontal coordinate of the same point is slightly to the right of 1950

A cone has a volume V, radius r, and a height of 12 cm.

a. A cone has the same height and $\frac{1}{3}$ of the radius of the original cone. Write an expression for its volume.

$\frac{V}{9}$ (or equivalent)

b. A cone has the same height and 3 times the radius of the original cone. Write an expression for its volume.

$9V$ (or equivalent)