CARNEGIE FOUNDATION SUMMIT on IMPROVEMENT IN EDUCATION 2020

Run Charts: A Tool for Analysis in Improvement Science

Jon Norman, Associate, Managing Director, Evidence and Analytics, Carnegie Foundation

Manuelito Biag, Senior Associate, Networked Improvement Science, Carnegie Foundation

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Carnegie Foundation
for the Advancement of Teaching

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Faculty

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Senior Associate,
Networked Improvement Science

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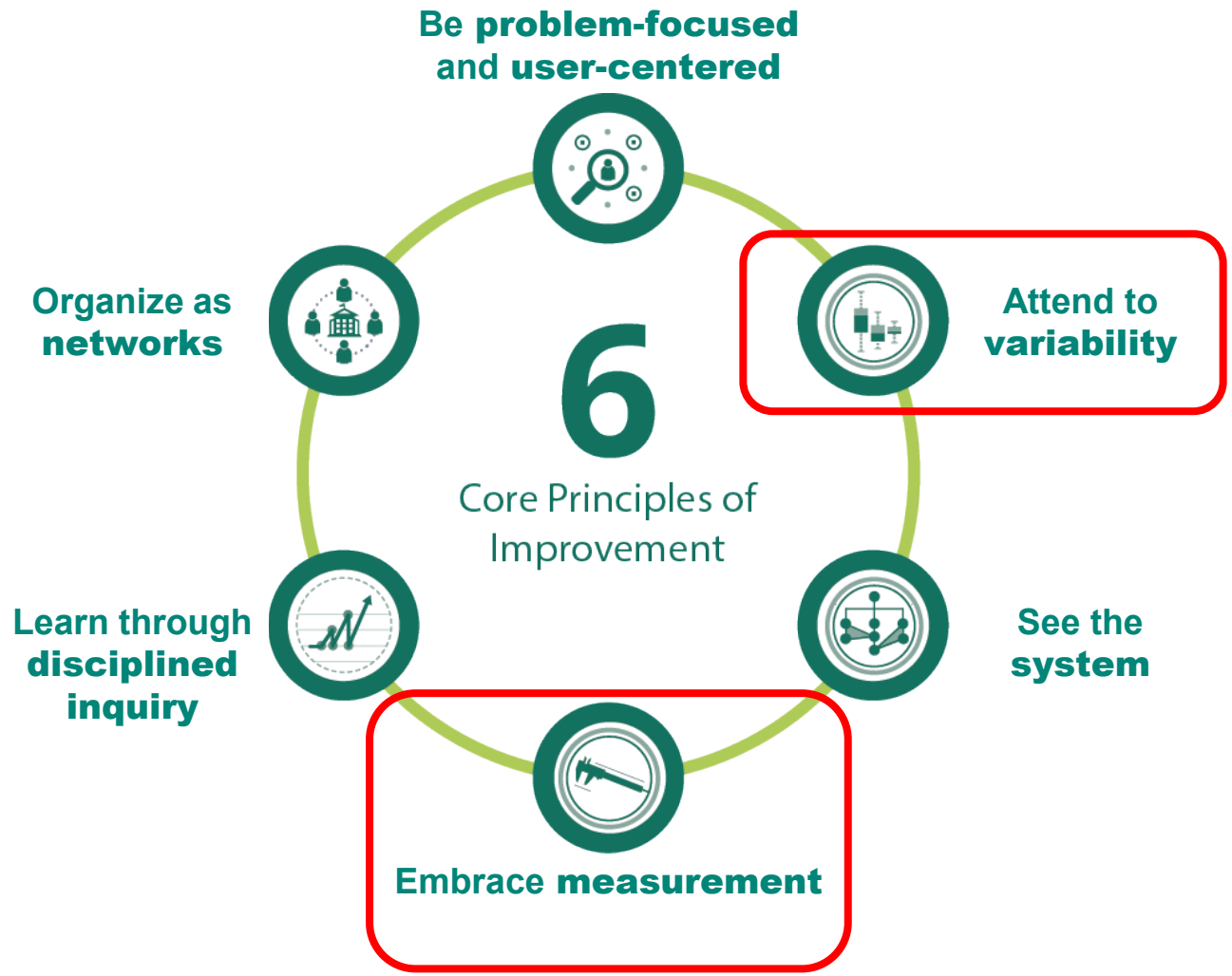
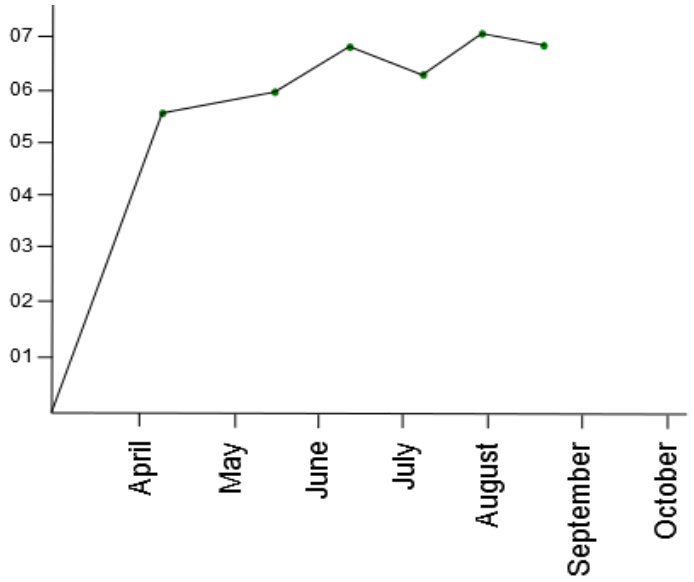
Session Objectives

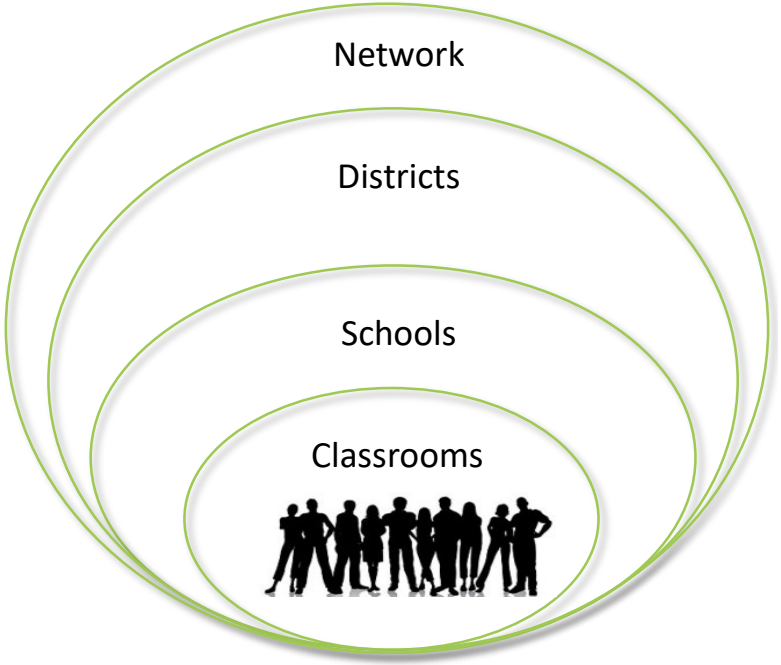
- Begin to understand the difference between measurement for improvement, research, and accountability
- Identify what a run chart is and how it's utilized in improvement efforts
- Understand the run chart rules and practice applying them to interpret data



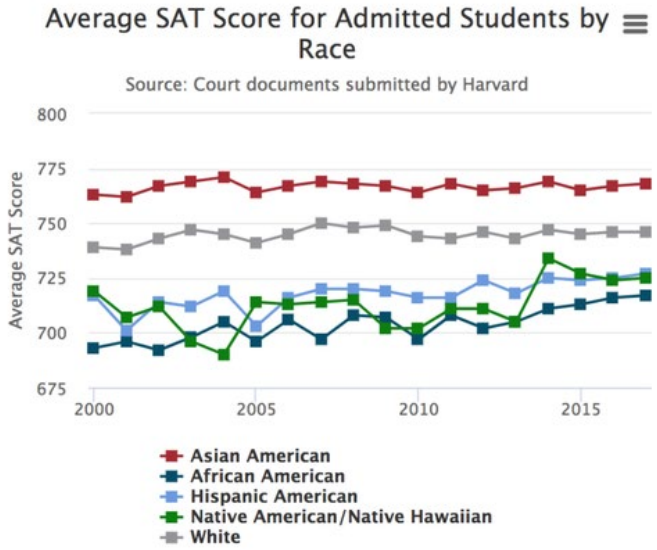
We Expect Variation: Our Job is to Understand It



Variation over time



Variation across “units”



Variation across students

ASPECT	IMPROVEMENT	ACCOUNTABILITY	RESEARCH
Why?	Develop and evaluate changes in practice	Identify exemplary or problematic performers (teachers, schools, districts)	Develop and test theories about the relationships between conceptual variables
What?	Outcomes and processes that are the object of change	End of the line outcomes	Latent variables
How often?	Frequently as practice occurs	Usually collected once a year (after the fact)	Typically once or twice per study (after the fact)
Testing your theory	Sequential tests	No theory to test	One large test
Sample size	"Just enough" data, small sequential samples	Obtain 100% of available, relevant data	"Just in case" data
Social Conditions of Use?	Data shared in a low-stakes, safe environment conducive to change.	Publically available. Formal collection process to assure appearances of neutrality and objectivity.	Meets scientific standards that are held in the field.

Lief Solberg, Gordon Mosser and Sharon McDonald *Journal on Quality Improvement* vol. 23, no. 3, (March 1997), 135-147.

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Does not illuminate why the outcomes occur or what should be done to change them

Lief Solberg, Gordon Mosser and Sharon McDonald *Journal on Quality Improvement* vol. 23, no. 3, (March 1997), 135-147.

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Impractical to administer; not designed to inform changes in practice

Lief Solberg, Gordon Mosser and Sharon McDonald *Journal on Quality Improvement* vol. 23, no. 3, (March 1997), 135-147.

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Supports the ongoing refinement of knowing what works for whom and under what conditions

Lief Solberg, Gordon Mosser and Sharon McDonald *Journal on Quality Improvement* vol. 23, no. 3, (March 1997), 135-147.

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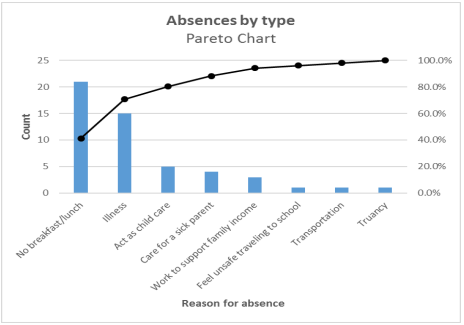
Different Visual Displays Can Help Our Understanding of the Data

Data display	When to use it?
Pareto charts	When there are many problems or causes and you want to focus on the most significant.



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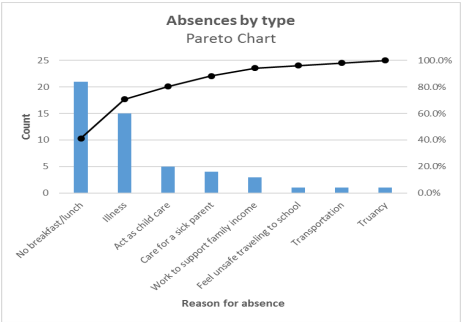

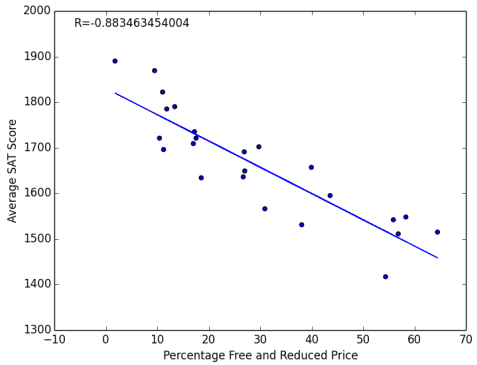

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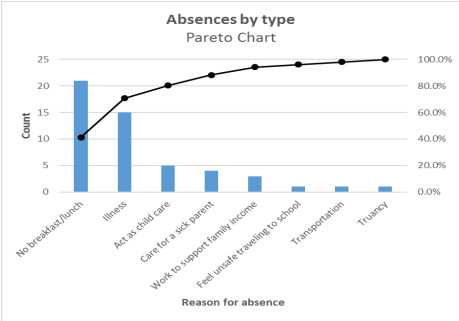
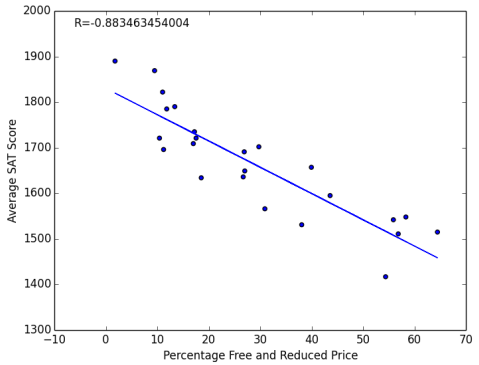
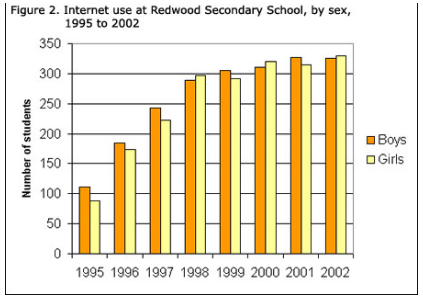
Scatter plots	When you want to understand the relationship between two variables (e.g., % free & reduced priced lunch, SAT scores)
Ordered bar charts	When you want to compare the number, frequency or other measure (e.g. mean) for different categories of data

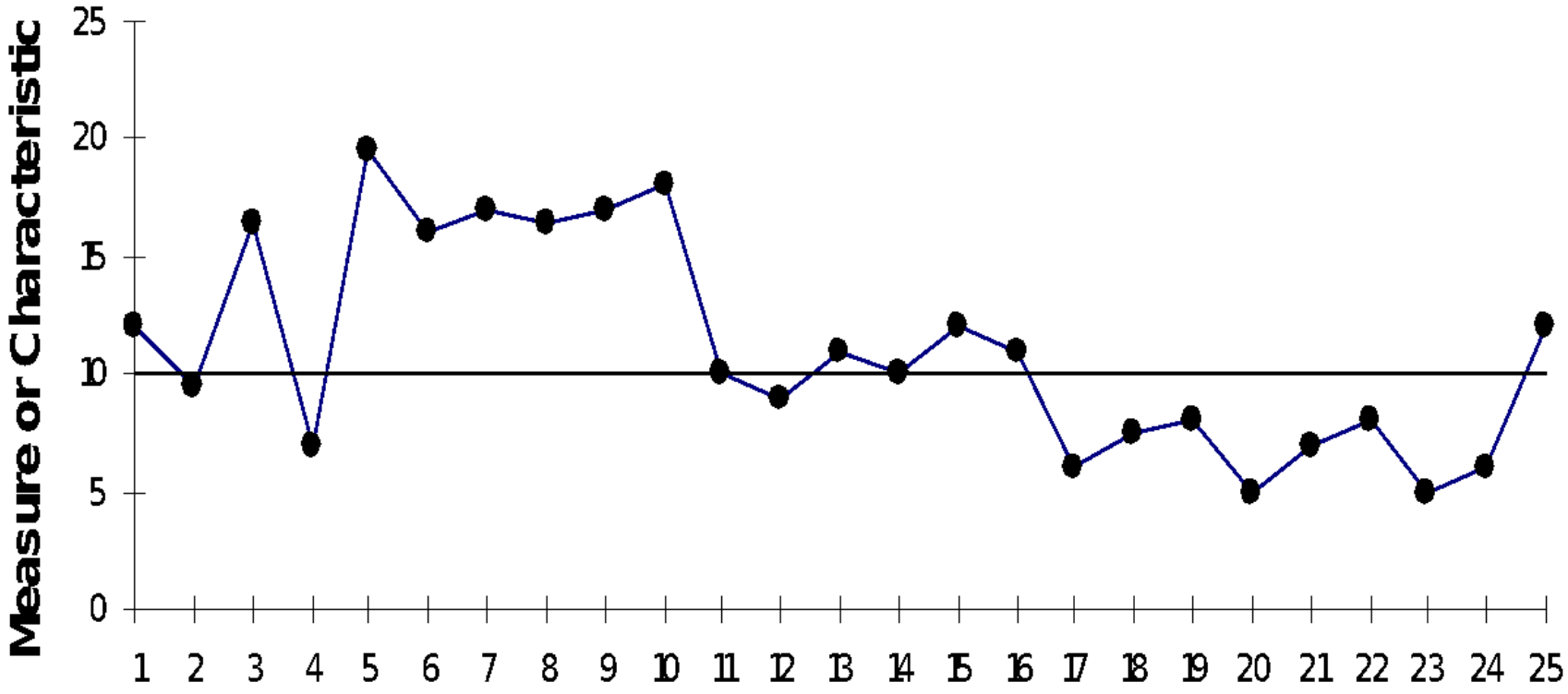




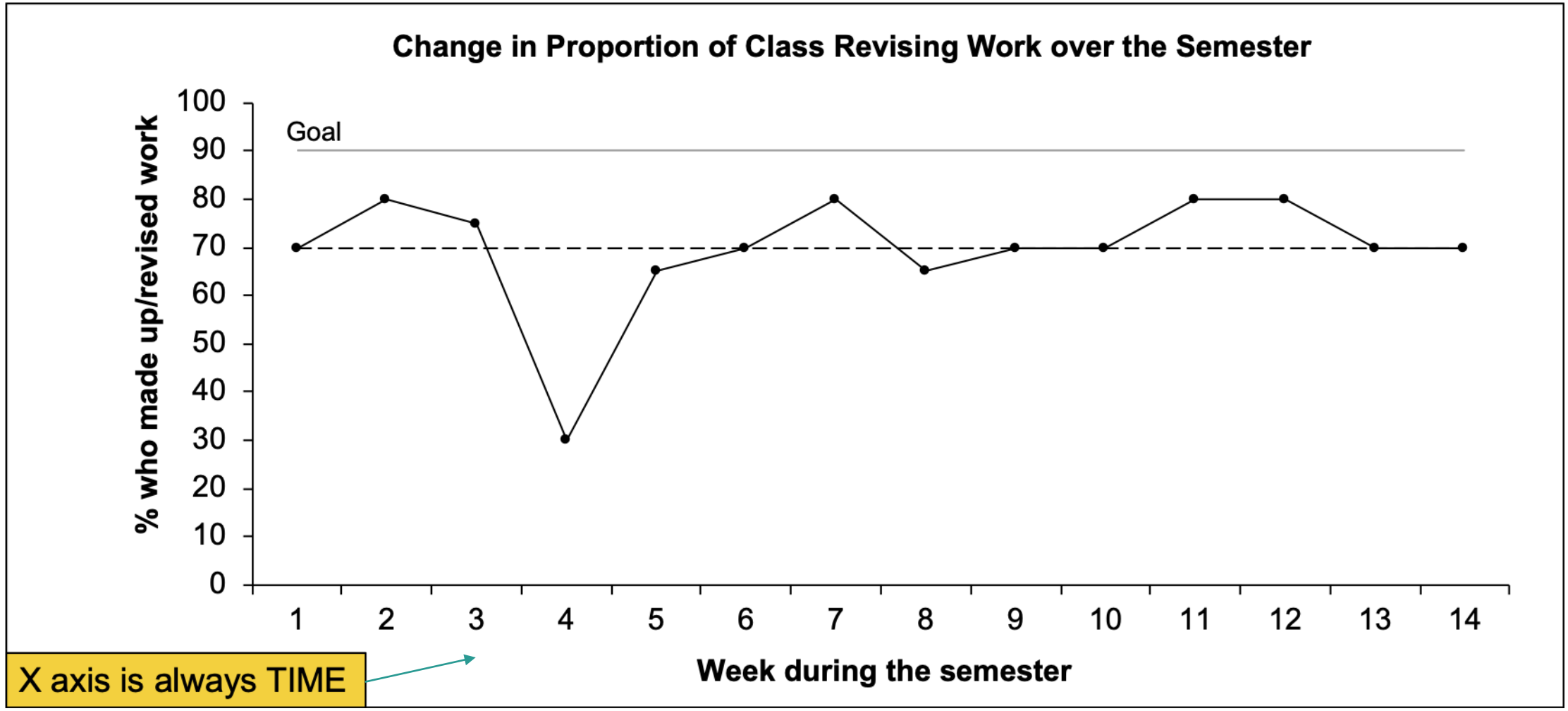


Tool for Understanding Variation: Run Charts

A run chart is a simple plot and display of data and trends within observation points over a specified period of time.



What are the Elements of a Run Chart?



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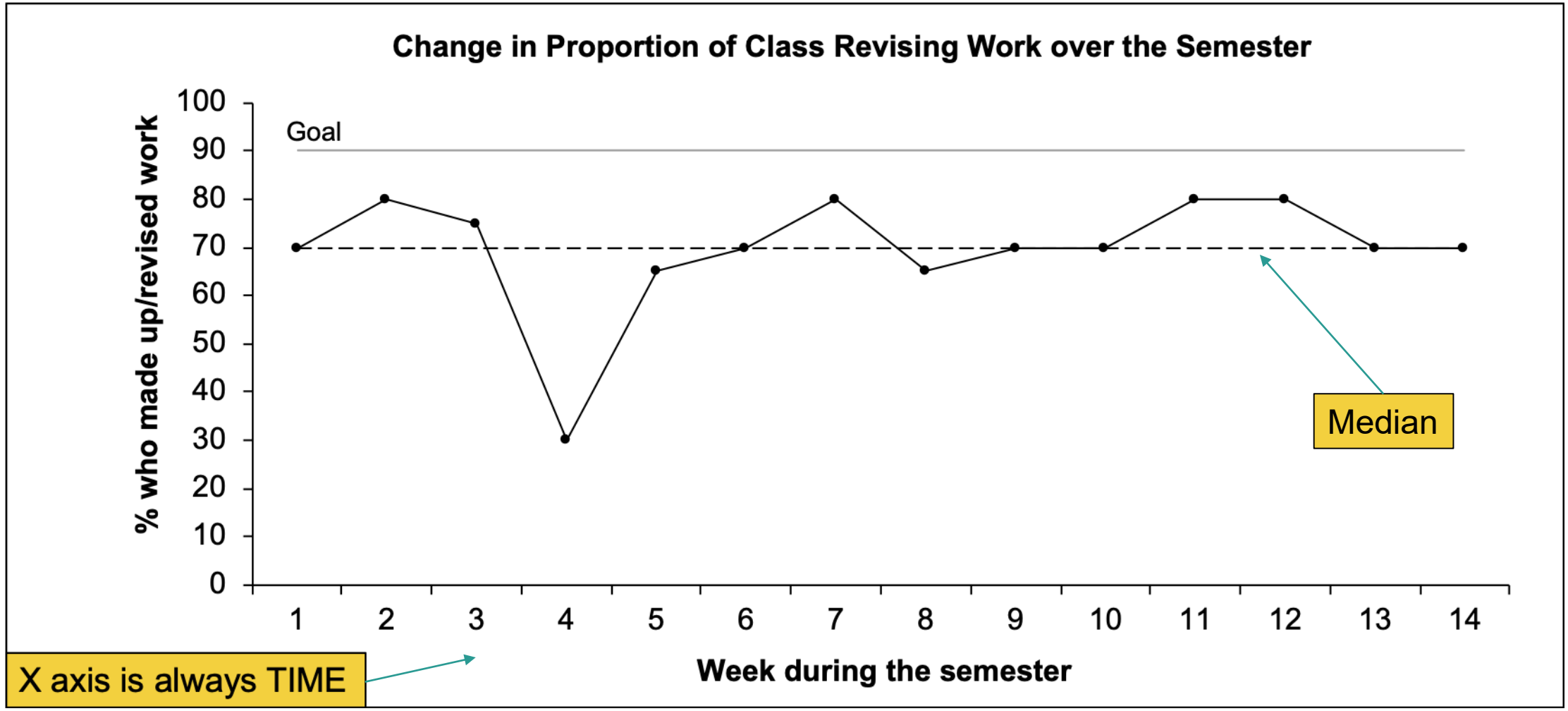

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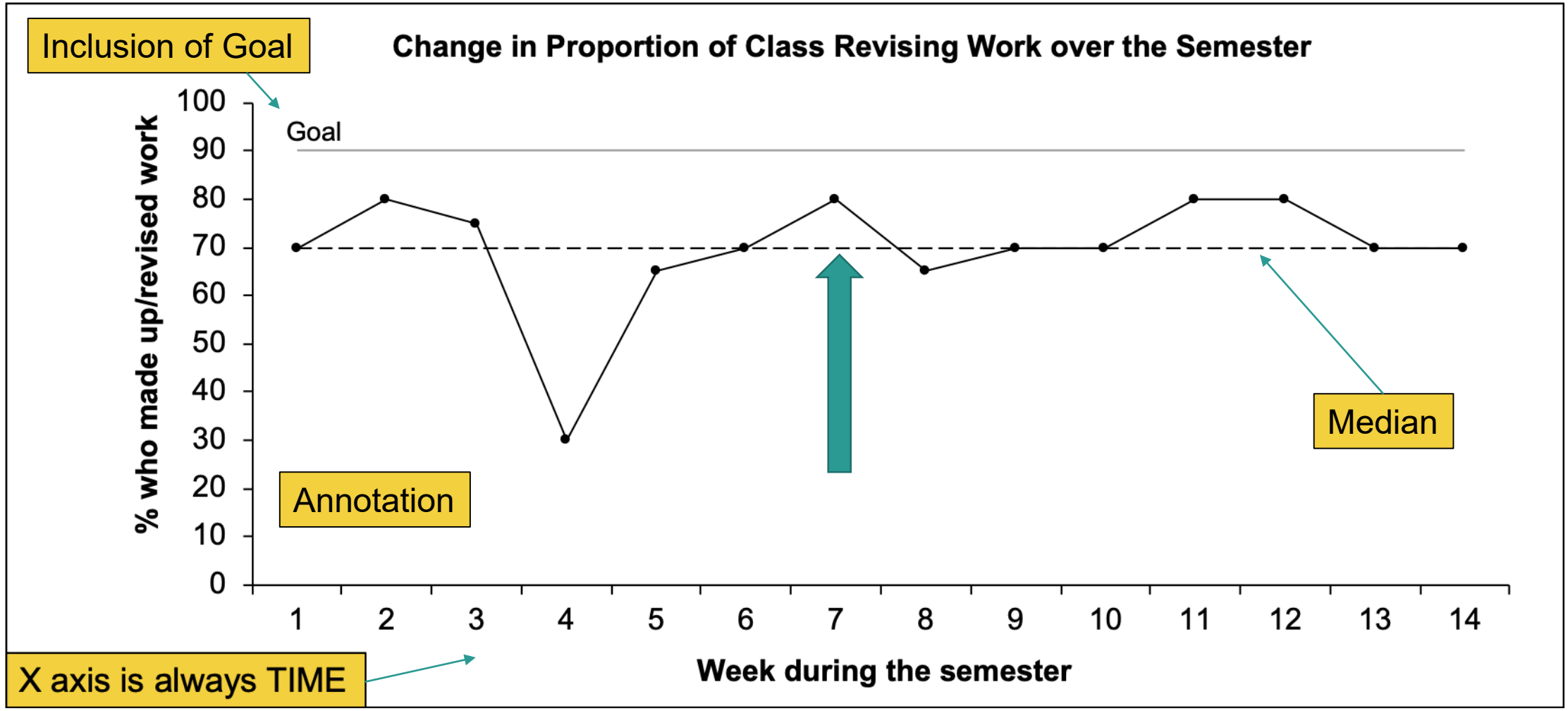
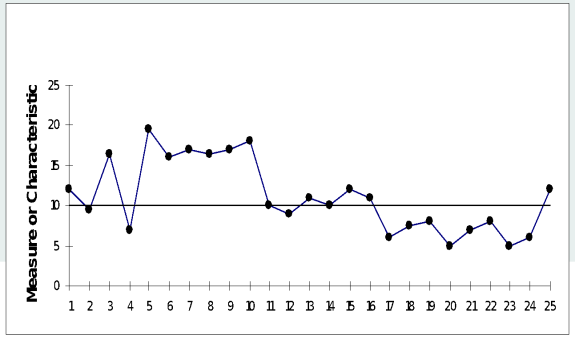


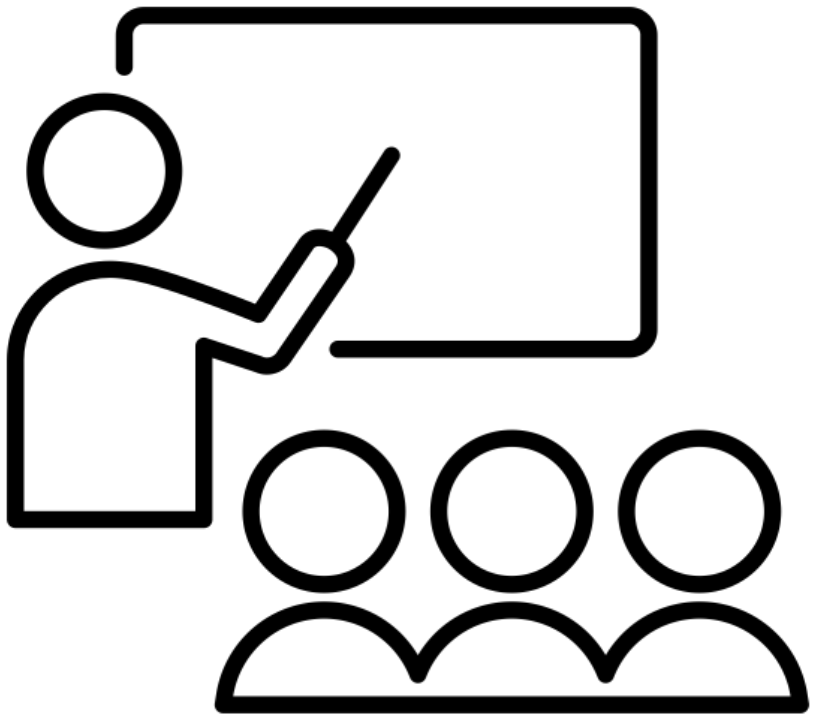
When Might Run Charts be Helpful?

When & Sample Uses	Description
When are run charts used?	• To monitor variation over time • To look for patterns (e.g., cycles, trends, or changes in the average) • To help assess whether a change is an improvement, and whether it's sustained
Some sample uses of run charts 	• To monitor variation in test scores over time • To monitor the number of tardies or unexcused absences over time • To monitor transition time between tasks • To determine whether changes to a process leads to improvements

Langford, D. (2015). *Tool time for education: Choosing and implementing quality improvement tools.* Road Molt, MT: Langford International Inc.

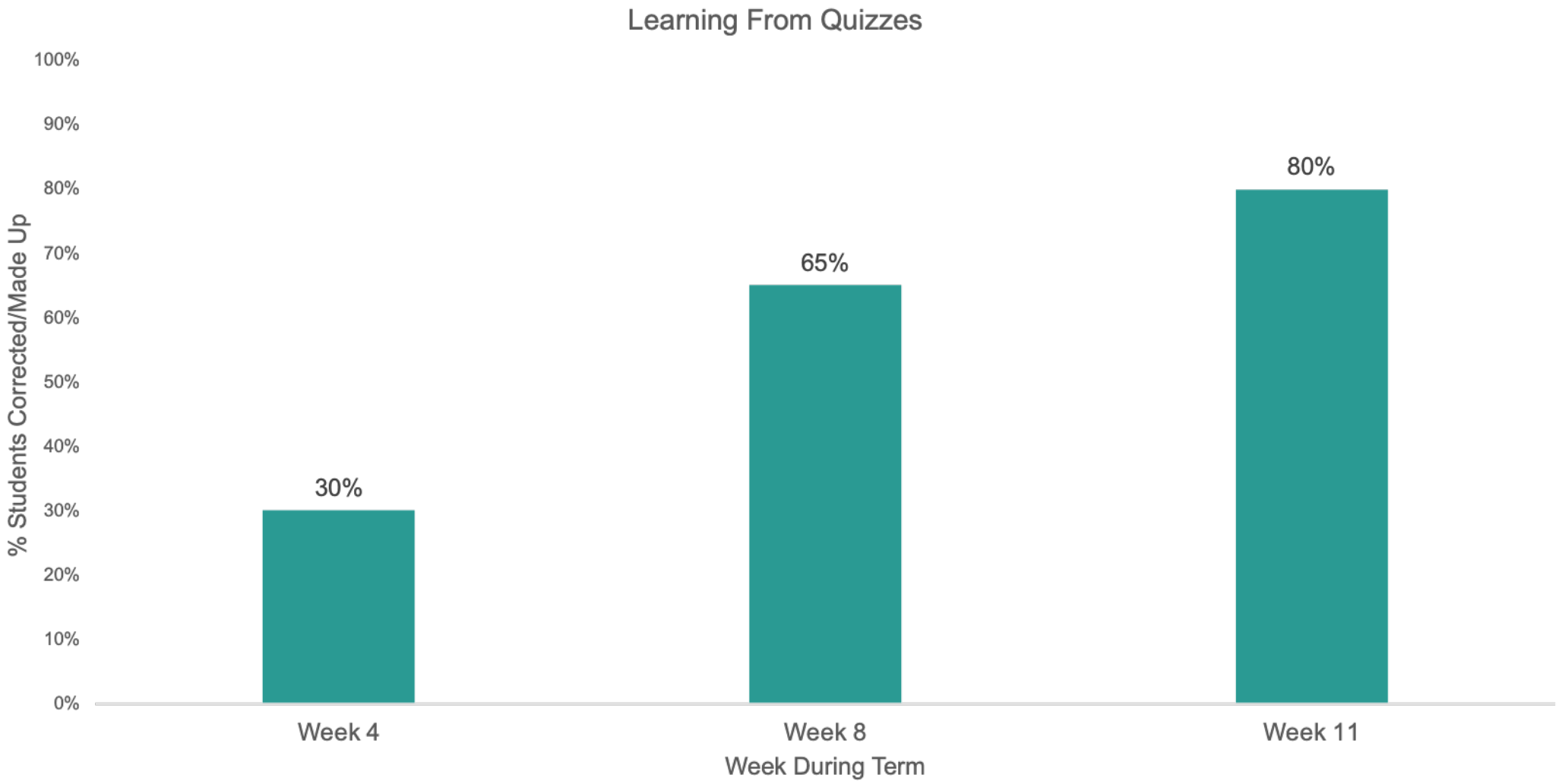
Why are run charts used?

Scenario



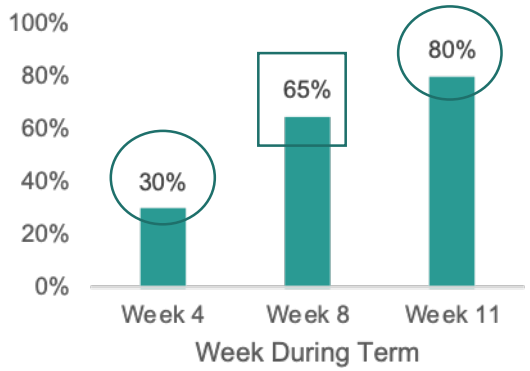
- An instructor has 35 students in his college math course and gives a weekly quiz.
- Every week, he records the percent of students who submit corrections to their quizzes for partial credit back on their scores.
- After the 7th week, he decides to implement a change to see if he can increase the number of students who engage in quiz corrections. He implements the change in time for the 8th quiz.
- It's now Week 11, and he decides to look at data before the change, in Week 4, around the time of the change, in Week 8, and after the change, in Week 11.

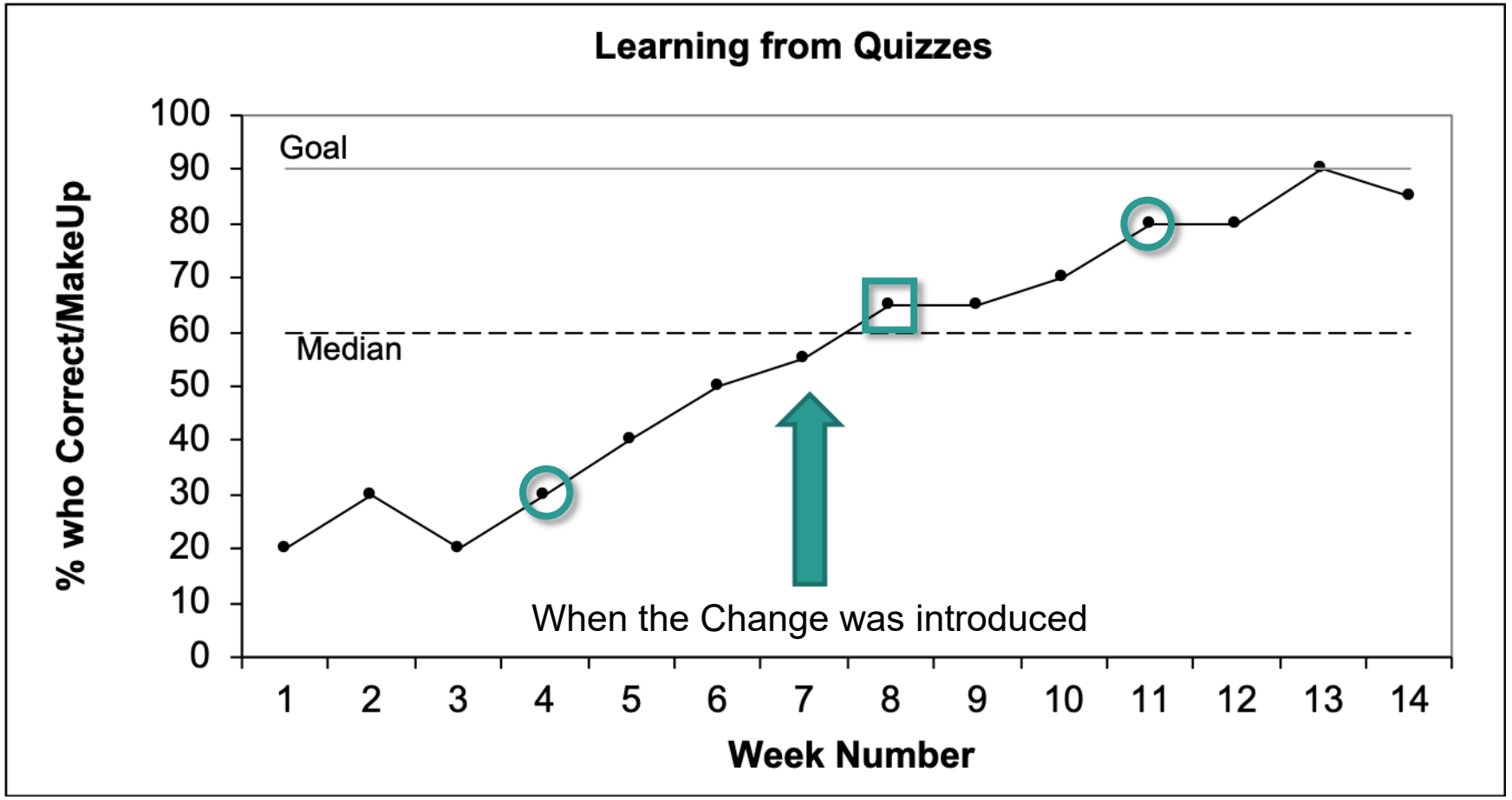
One Way to Look at the Results



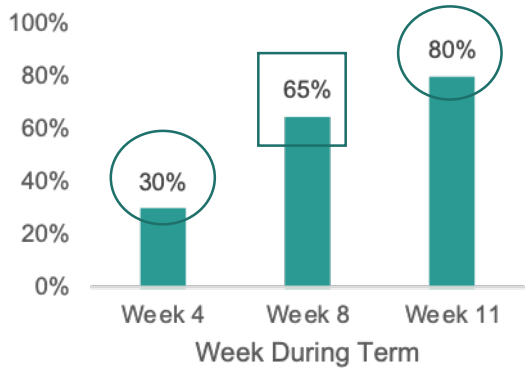
But when data over time are presented as snapshots, they can be misleading…

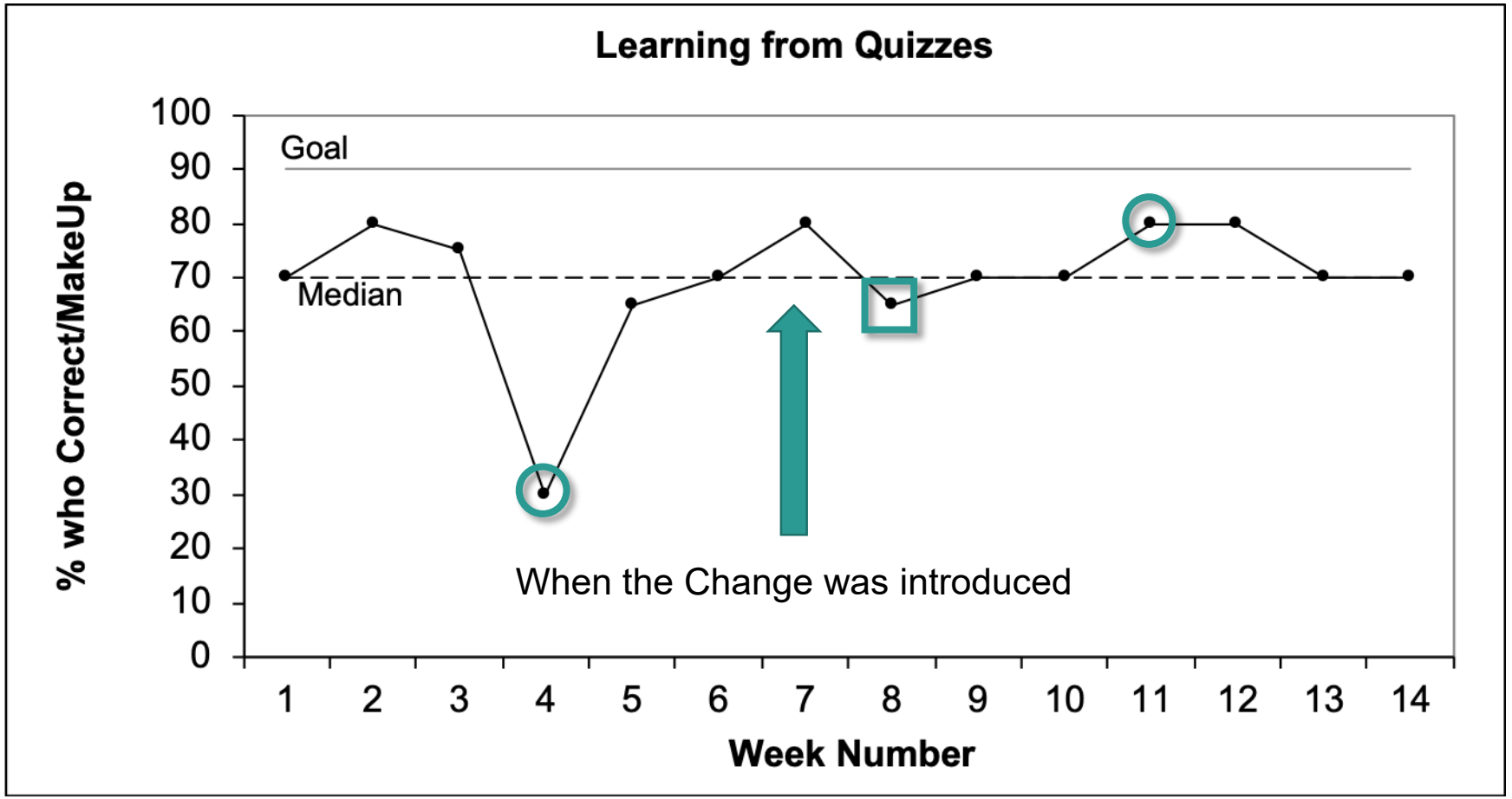
Linear Improvement, Likely Unrelated to the Change



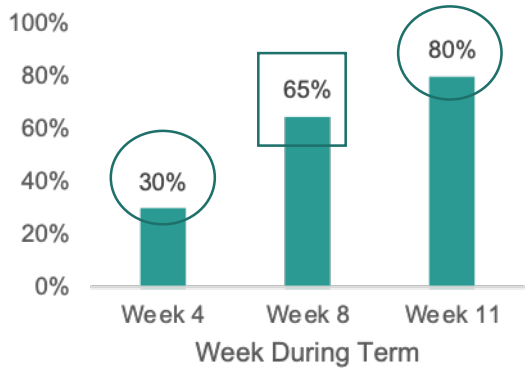


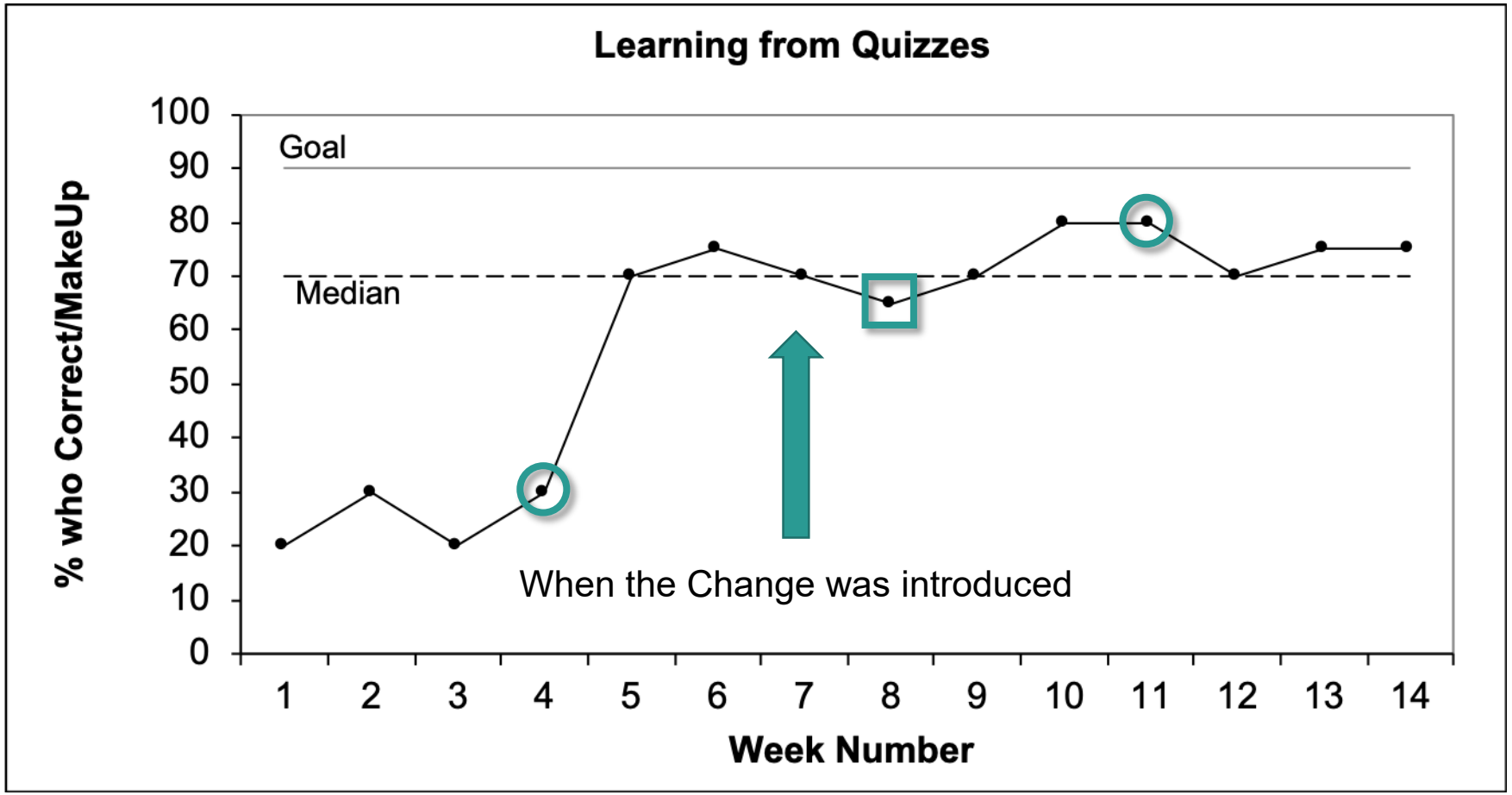
A “Blip” in a Steady Pattern



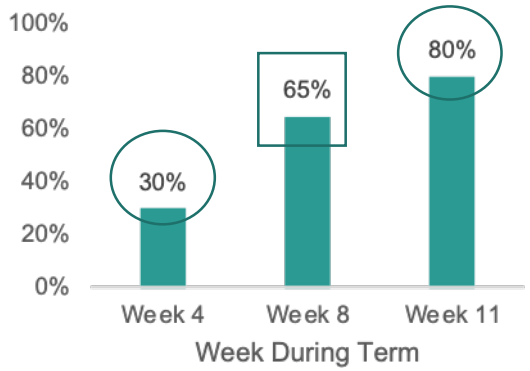


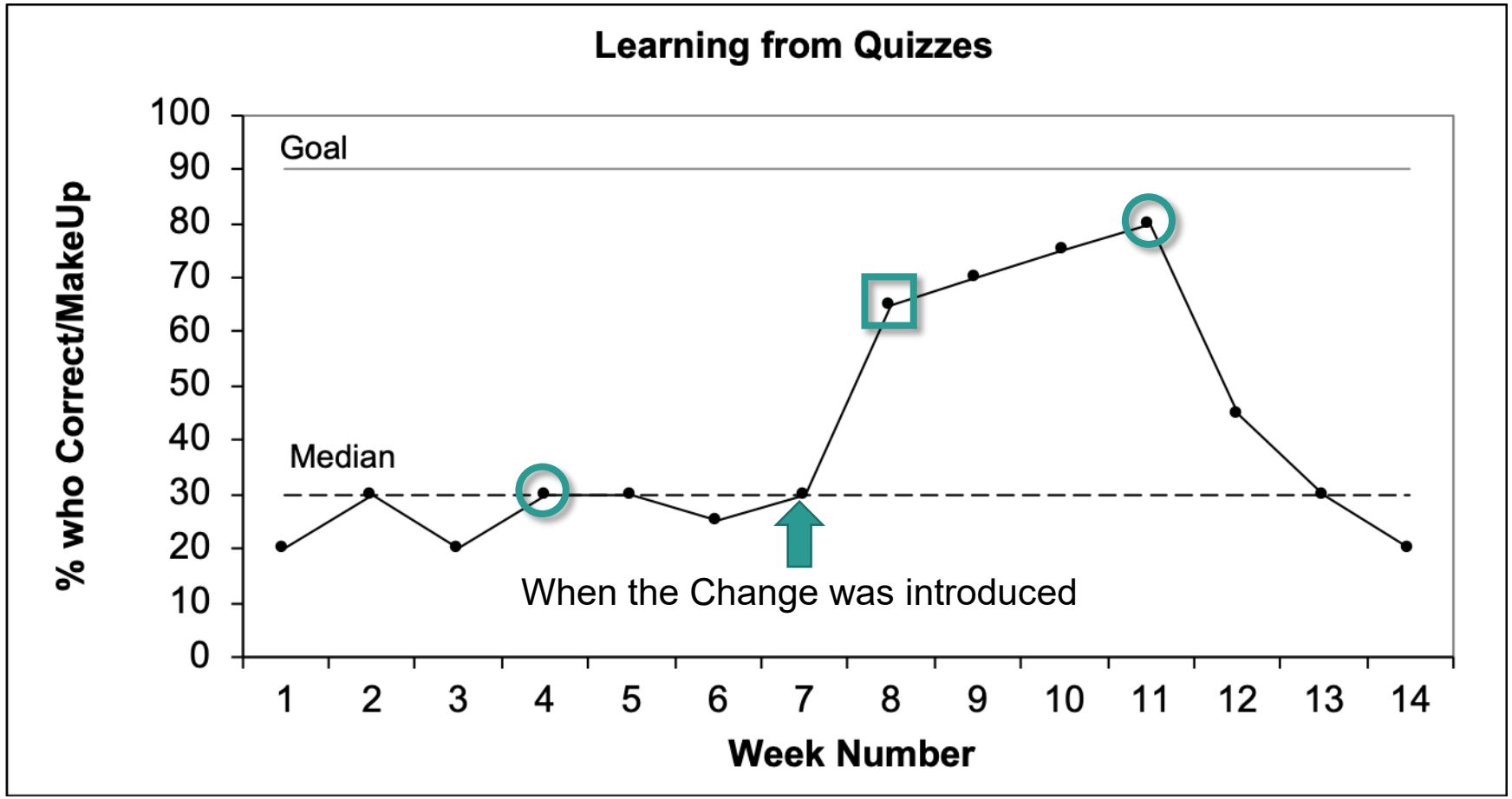
A Sudden Improvement…
but Not When There Was a Change!



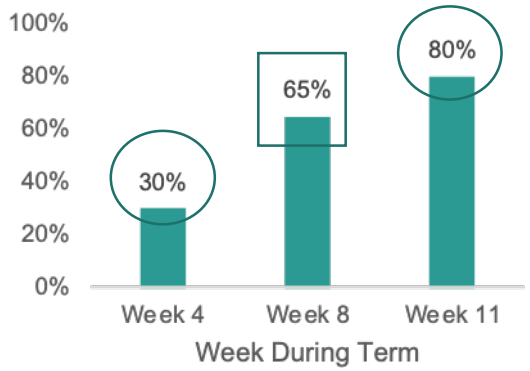


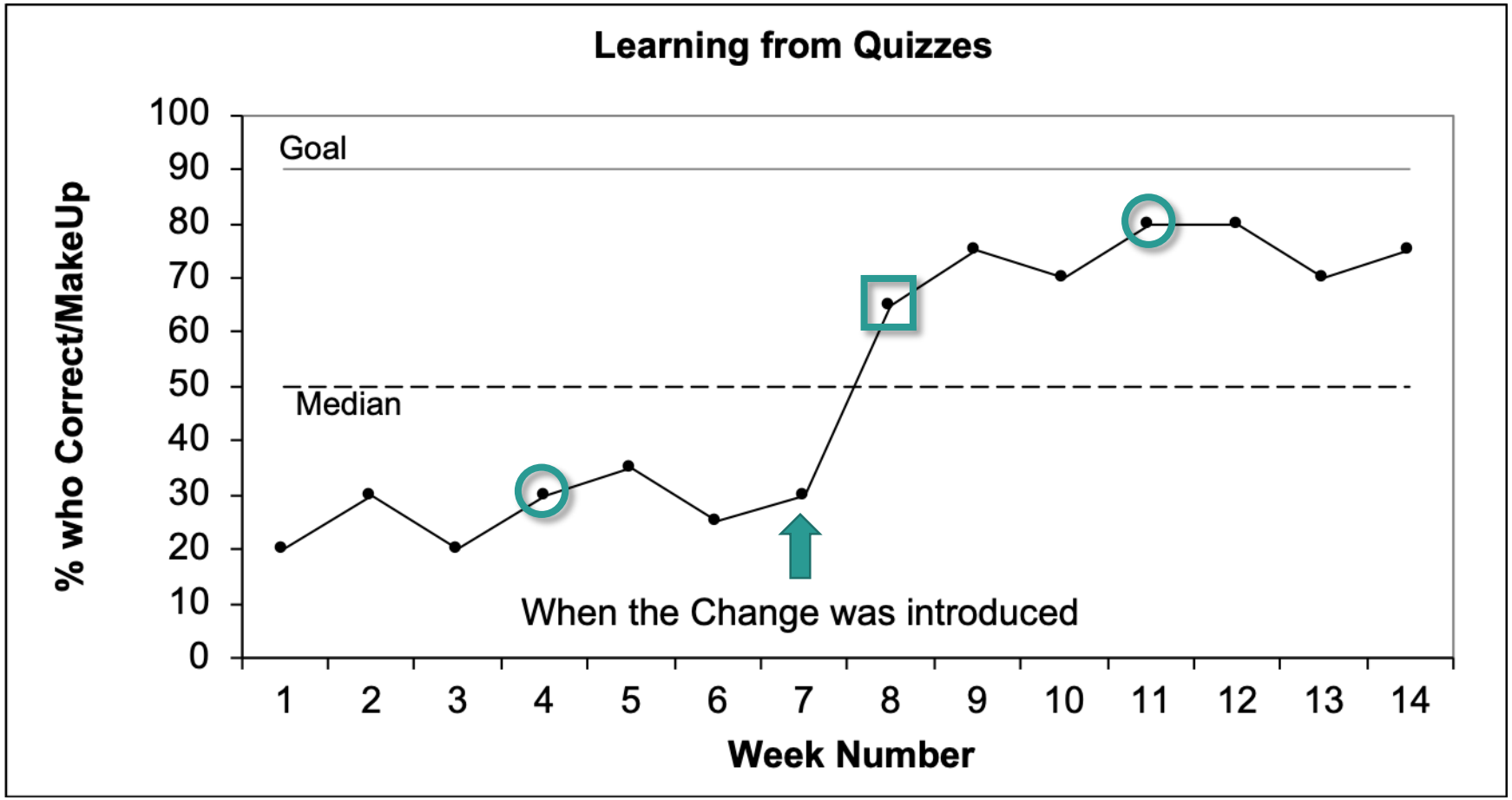
A Sudden Improvement, After the Change… but Not Sustained





A Change Is an Improvement!



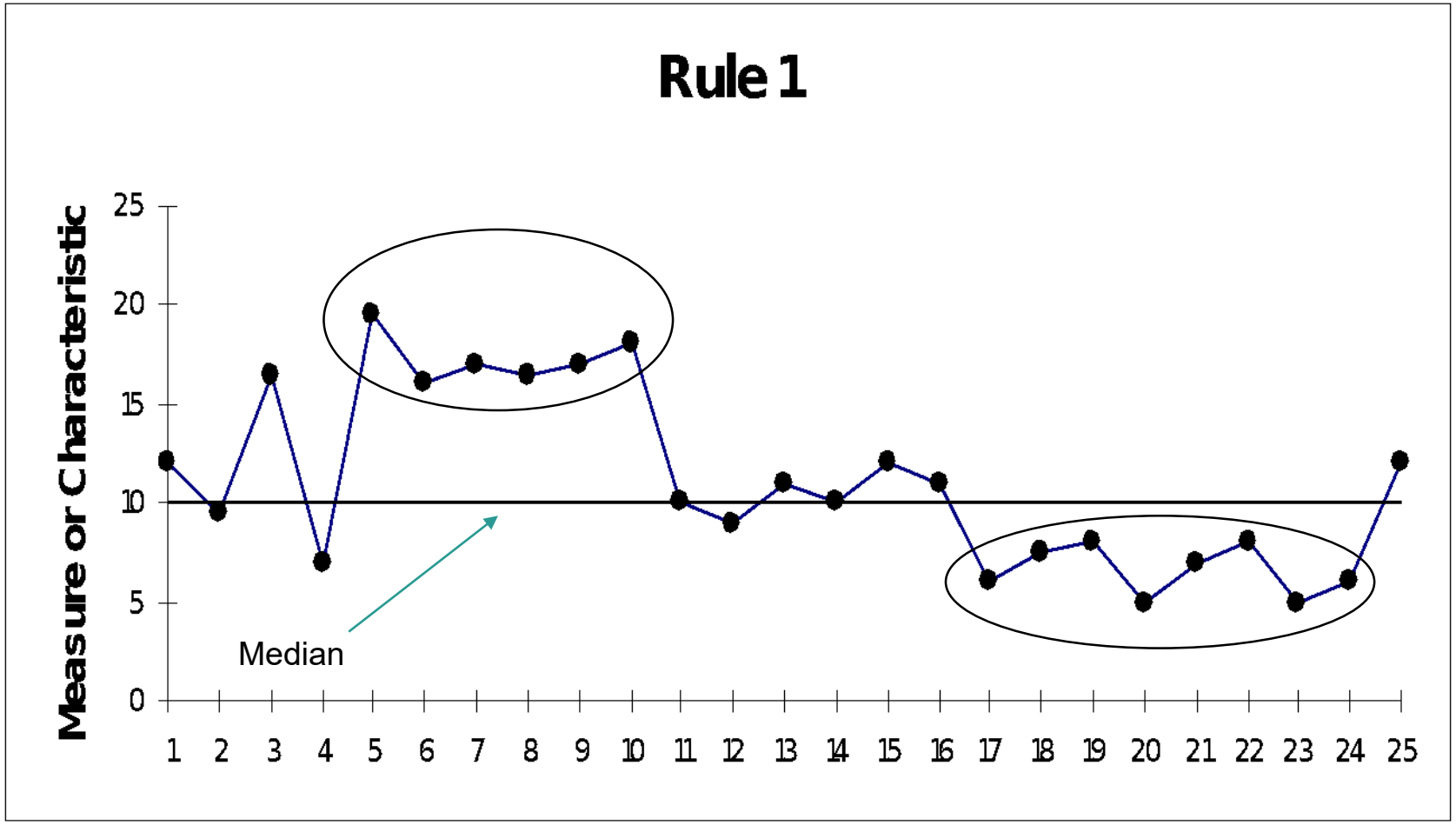


How do we determine “signal” from “noise” in a run chart?

Rules for Examining Run Charts for Signals

- We have **four rules** to decide when the data give us a “signal” of change – helping us know if a change is an improvement
- These rules are intended to support our visual analysis
  1. Shift
  2. Trend
  3. Too many or too few runs
  4. Astronomical data point

Rule 1: Shifts in Consecutive Points



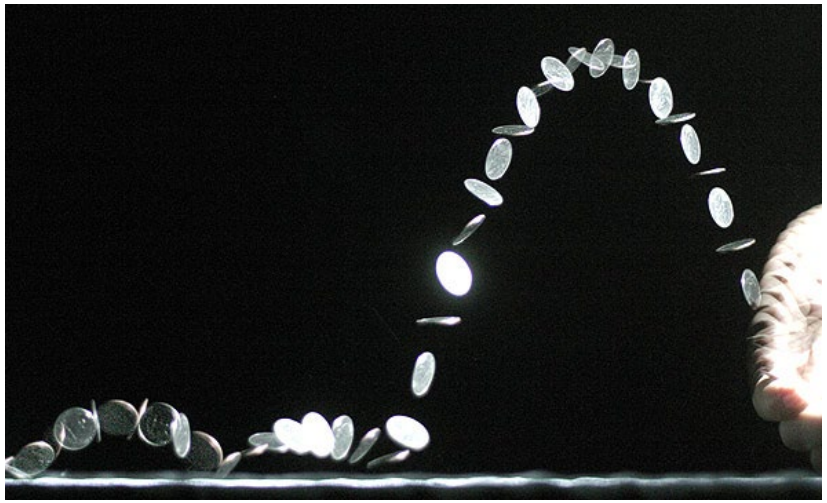
- **Six (6) or more consecutive points that are all either above or below the median constitute a *shift*.**
- **Skip values on the median and continue counting points.**
- **Values on the median DO NOT make or break a shift.**

Provost & Murray 2011

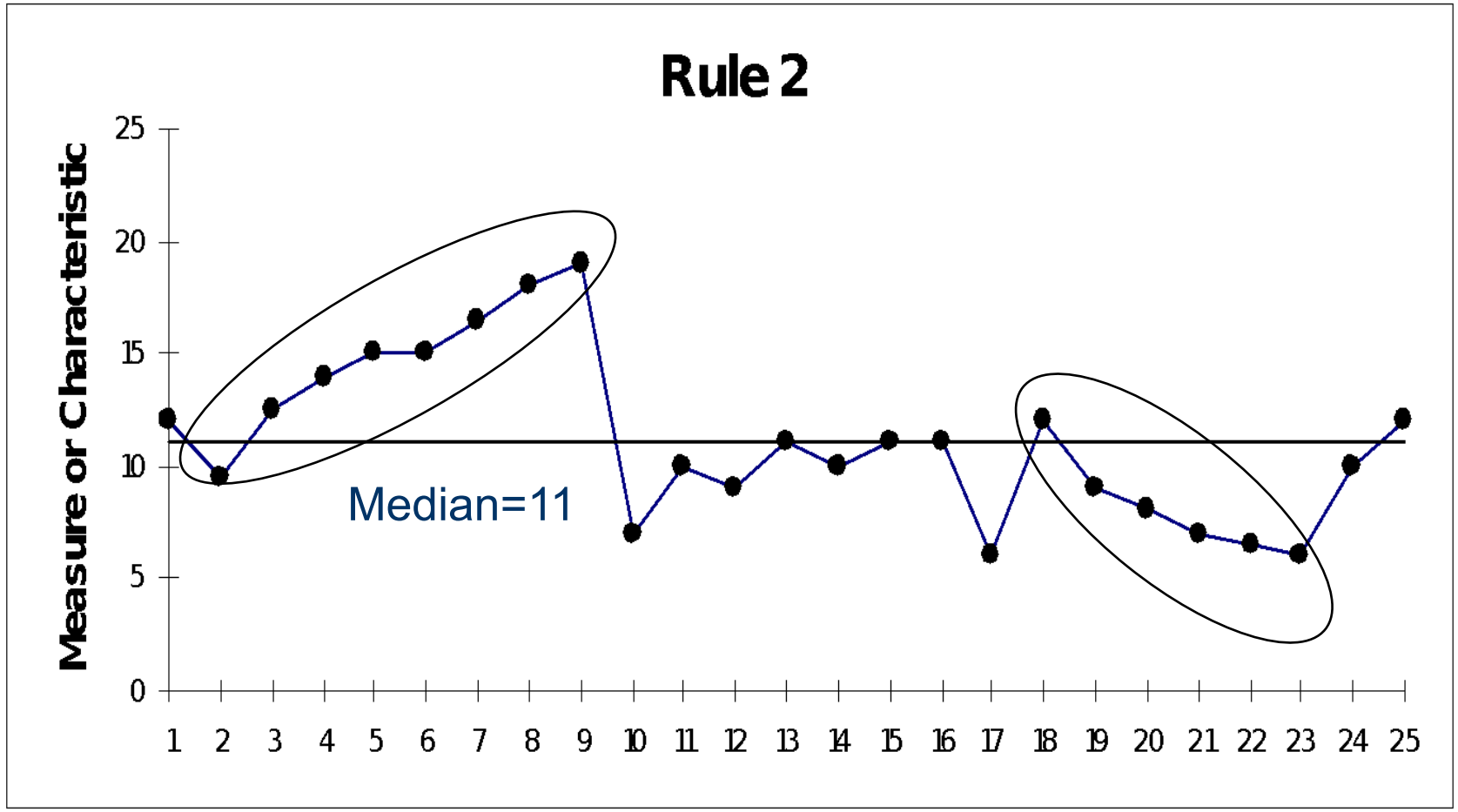
Why Do We Need 6 Points?

- What is the probability of a coin landing heads or tails?

- .5
- .5 x .5 = .25
- .5 x .5 x .5 = .125
- .5 x .5 x .5 x .5 = .0625
- .5 x .5 x .5 x .5 x .5 = .03125
- .5 x .5 x .5 x .5 x .5 x .5 = .015625



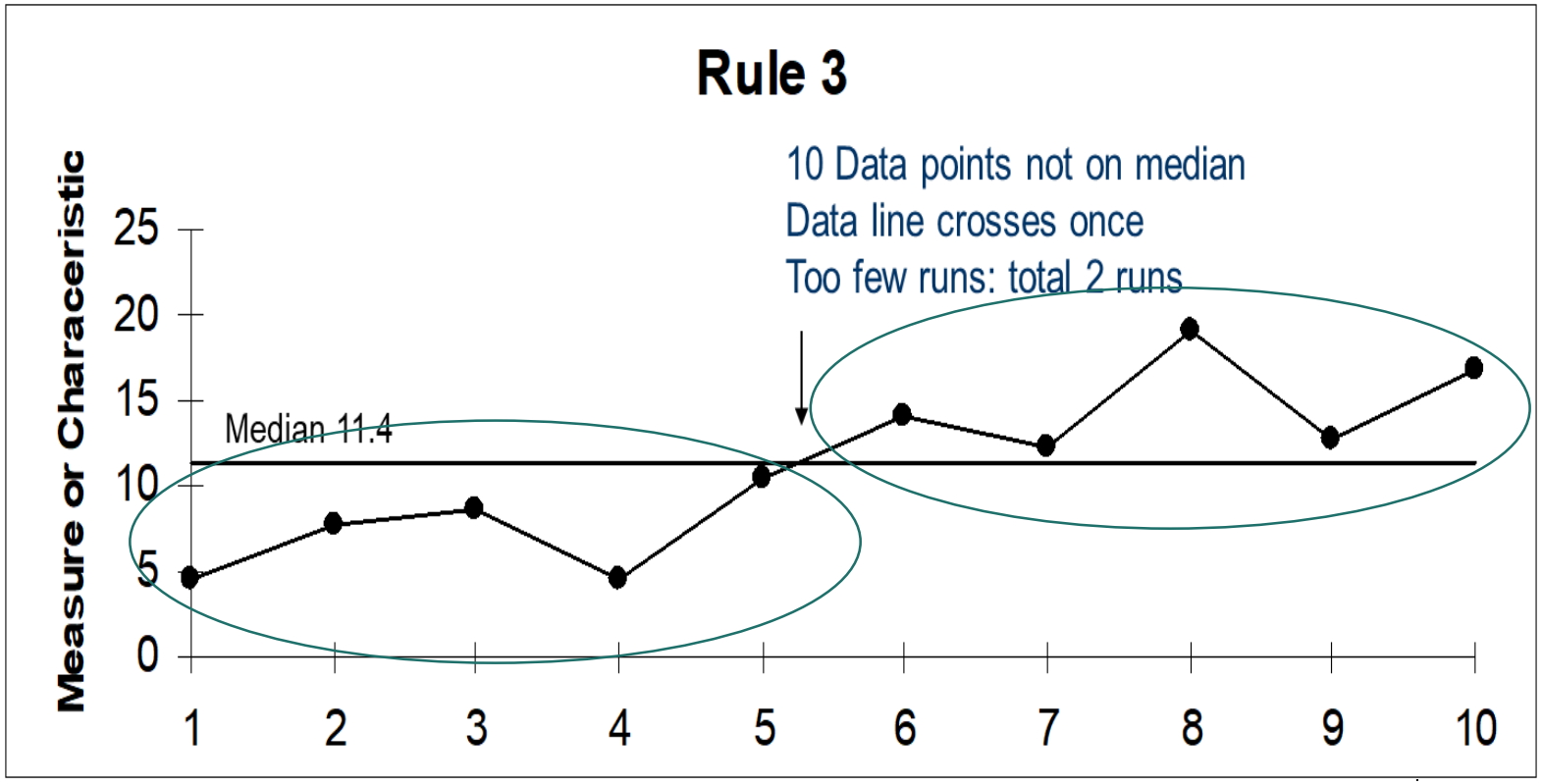
Rule 2: Trends in Data



- **Five (5) CONSECUTIVE points all going up or all going down constitutes a *trend*.**
- **If the values of two or more successive points are the same, skip those points and continue counting.**
- **Two of the same values in a row do not make or break a trend.**

Provost & Murray 2011

Rule 3: Too Few or Too Many Runs



- **A NON-RANDOM pattern in the data is signaled by too few or too many consecutive (non-median) points, called *runs*.**
- **A run is a series of consecutive points on one side of the median line.**
- **We look for the number of times the data LINE crosses the median (i.e., one crossing = two runs)**

Rule 3: Too Few or Too Many Runs

Total Number of Data Points on the Run Chart that DO NOT Fall on the Median	Lower Limit of the Number of Runs	Upper Limit of the Number of Runs
10	3	9
11	3	10
12	3	11
13	4	11
14	4	12
15	5	12
16	5	13
17	5	13
18	6	14
19	6	15
20	6	16
21	7	16
22	7	17
23	7	17

Adapted from Swed, Feda S. and Eisenhart, C. (1943). "Tables for Testing Randomness of Grouping in a Sequence of Alternatives. Annals of Mathematical Statistics. Vol. XIV, pp.66 and 87, Tables II and III.

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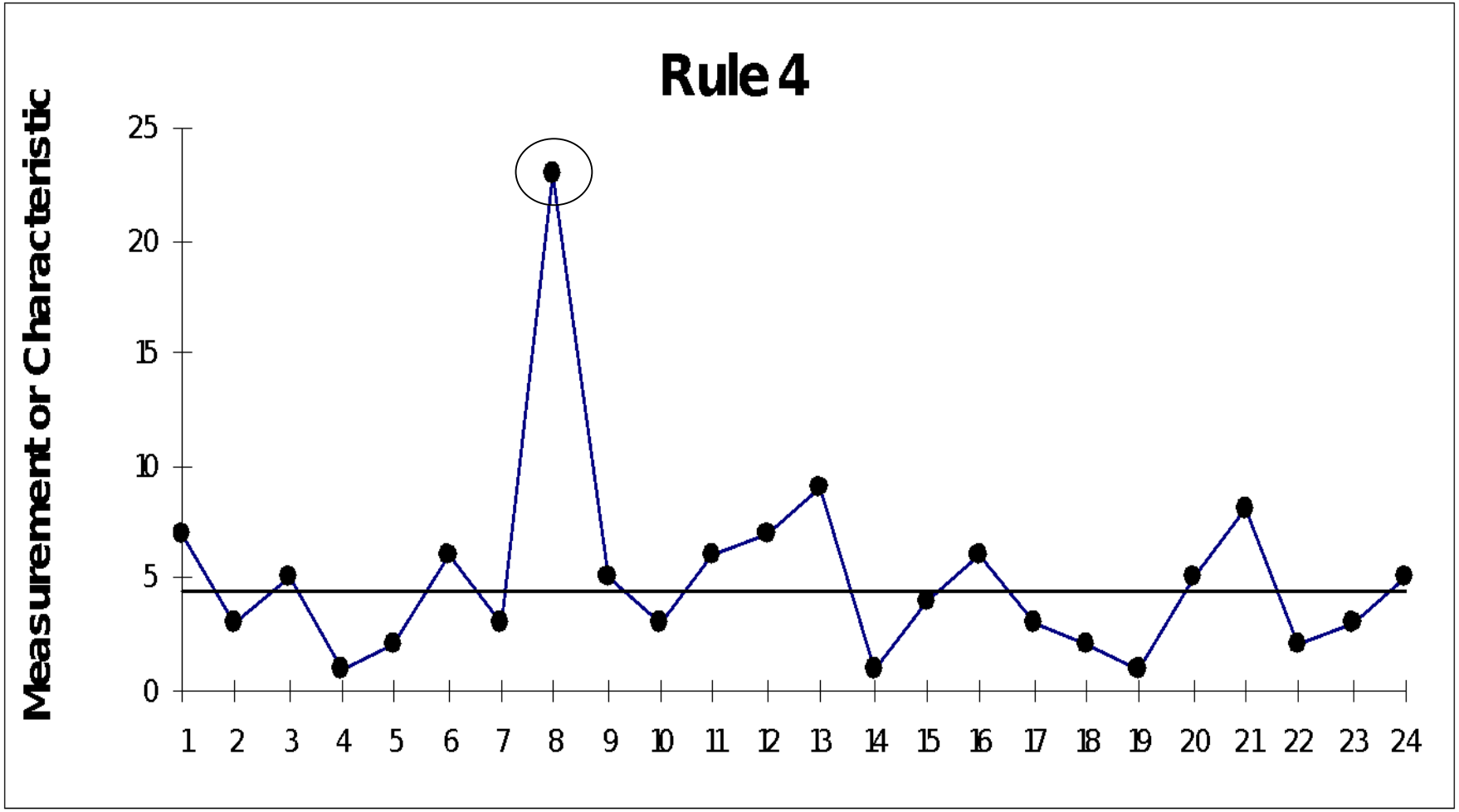
Rule 4: Astronomical Points



- **A data point that is obviously, even blatantly a different value constitutes an *astronomical point.***

  Everyone studying the chart agrees that it is unusual.

  Remember: every data set will have a high and a low - this does not mean the high or low are astronomical.

Murray and Provost

Activity: Applying the Rules

Scenario: Has There Been a Shift in Absenteeism?

Here's an opportunity to apply the four rules:

You are reviewing data from four schools in your district that are all working on curbing absenteeism

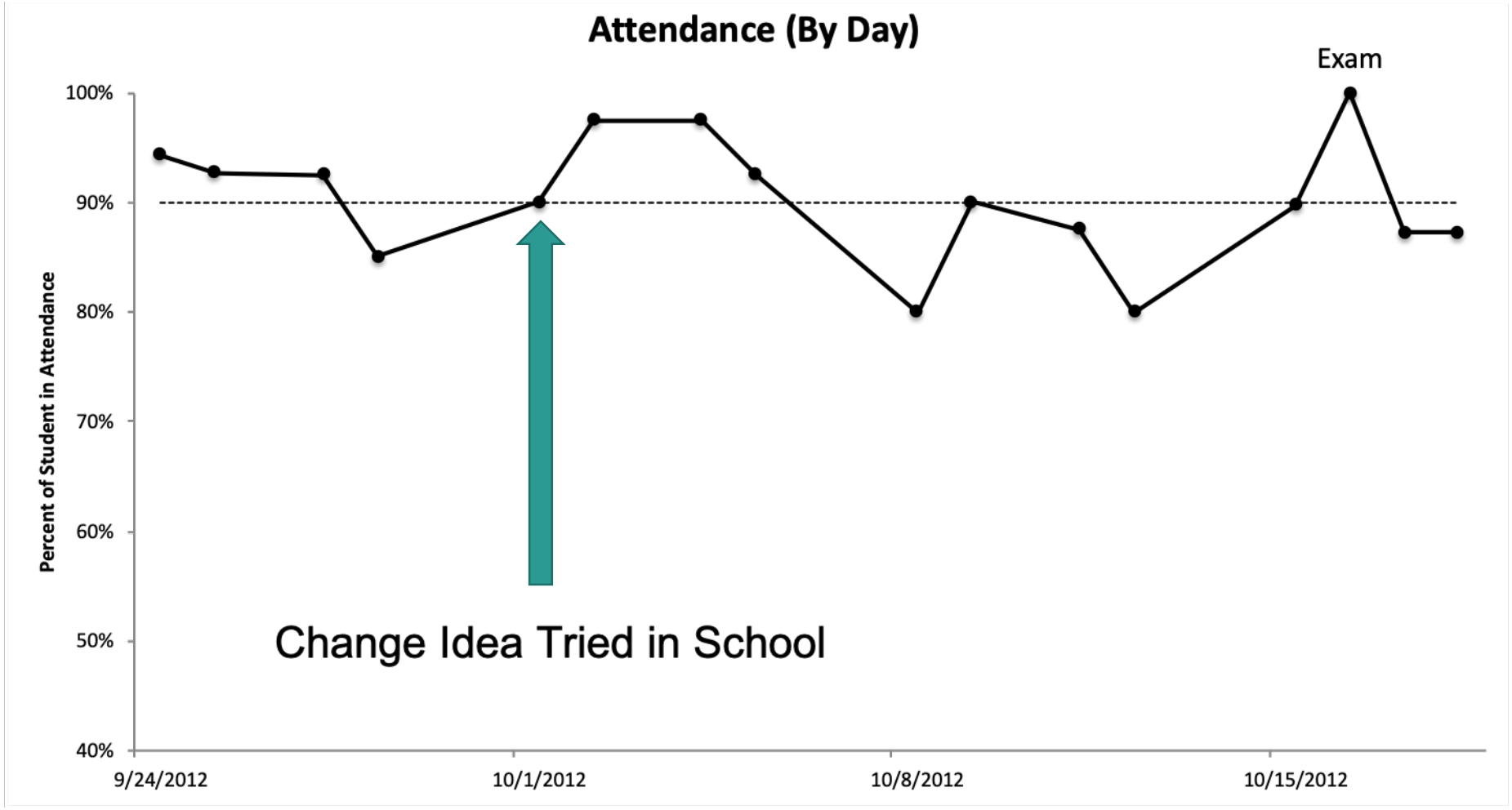
1. Which rules apply to each graph?

1. Can you tell if there's been an actual shift in attendance over the time captured in the graphs?

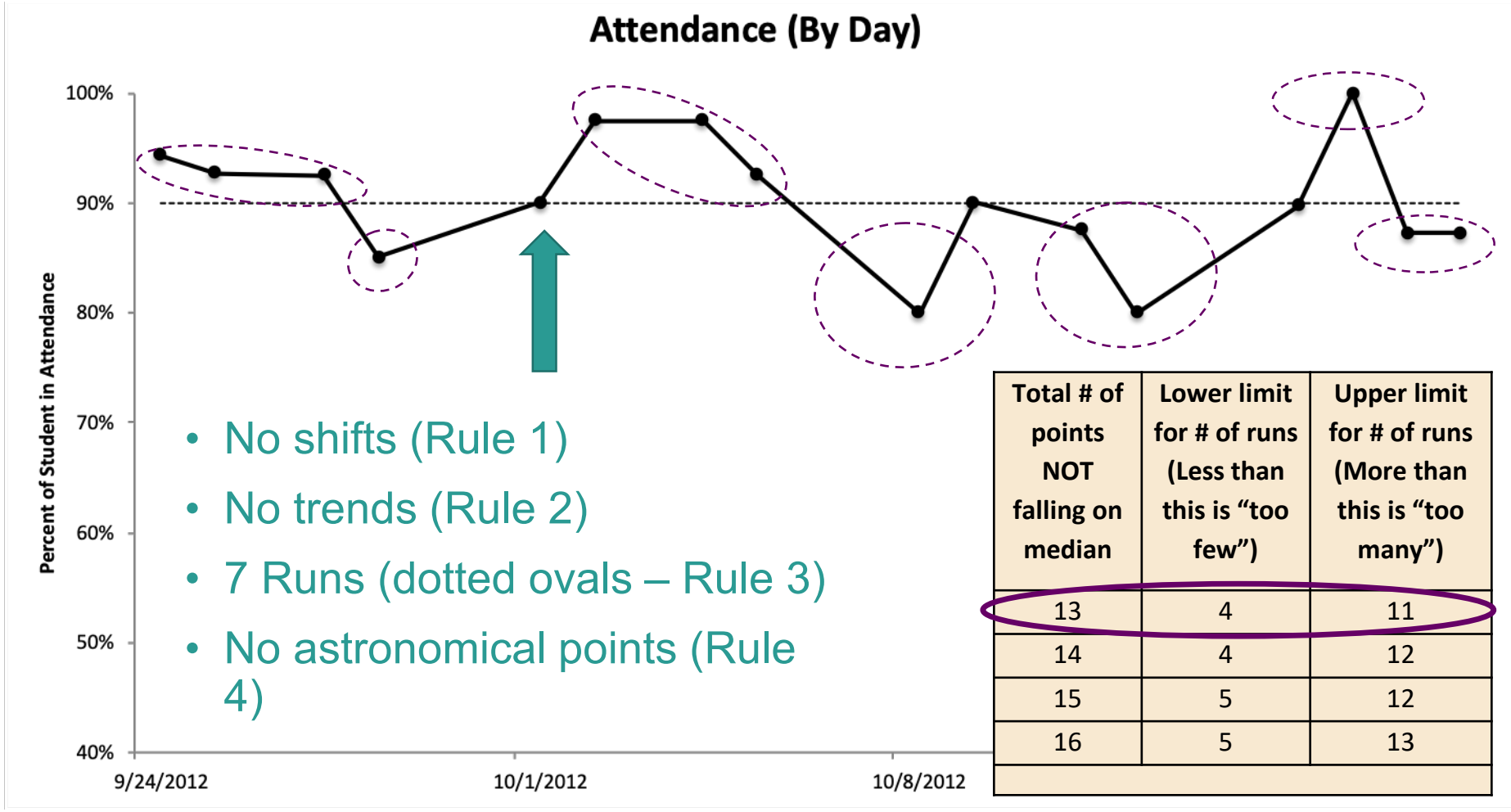
Scenario: Has There Been a Shift in Absenteeism?

- For each graph, determine which rules (if any) apply to the data
- We will provide the answers following each example
- The handout has the four graphs (one from each school)
- The handout also has the four run chart rules for looking for signals in the data

Example 1: Do Any Rules Apply?



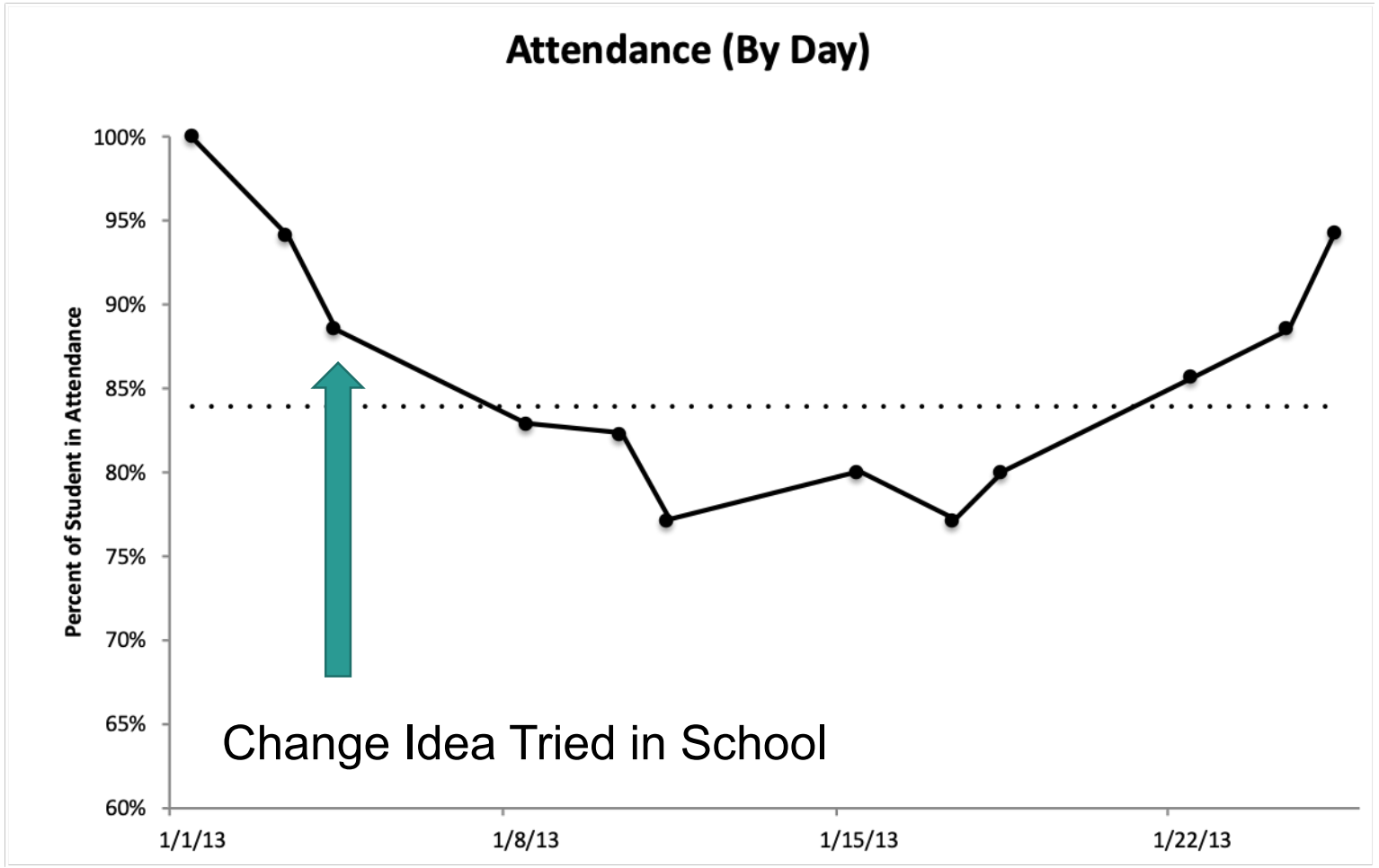
Example 1: Analysis



- No shifts (Rule 1)
- No trends (Rule 2)
- 7 Runs (dotted ovals – Rule 3)
- No astronomical points (Rule 4)

Total # of points NOT falling on median	Lower limit for # of runs (Less than this is "too few")	Upper limit for # of runs (More than this is "too many")
13	4	11
14	4	12
15	5	12
16	5	13

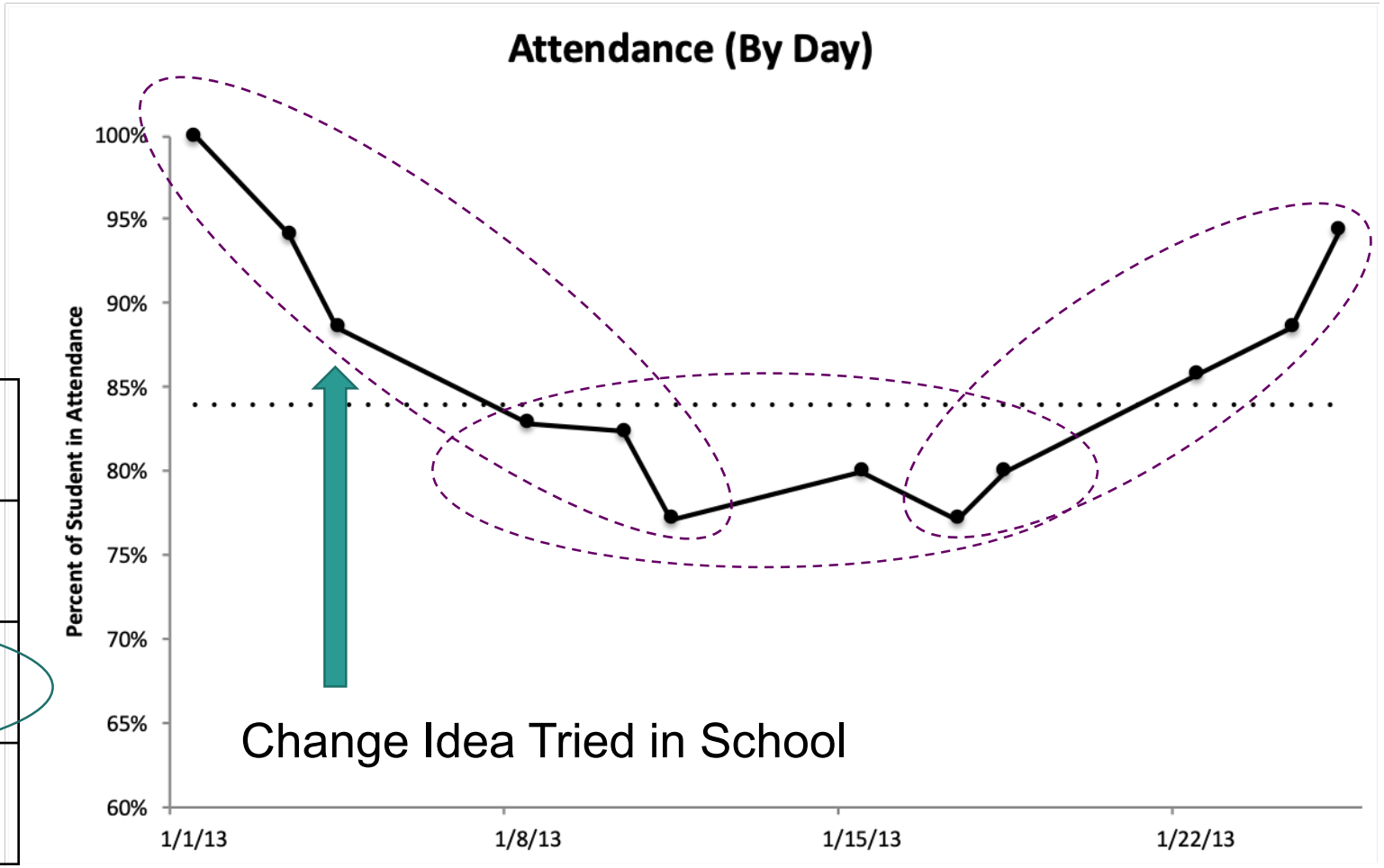
Example 2: Do Any Rules Apply?



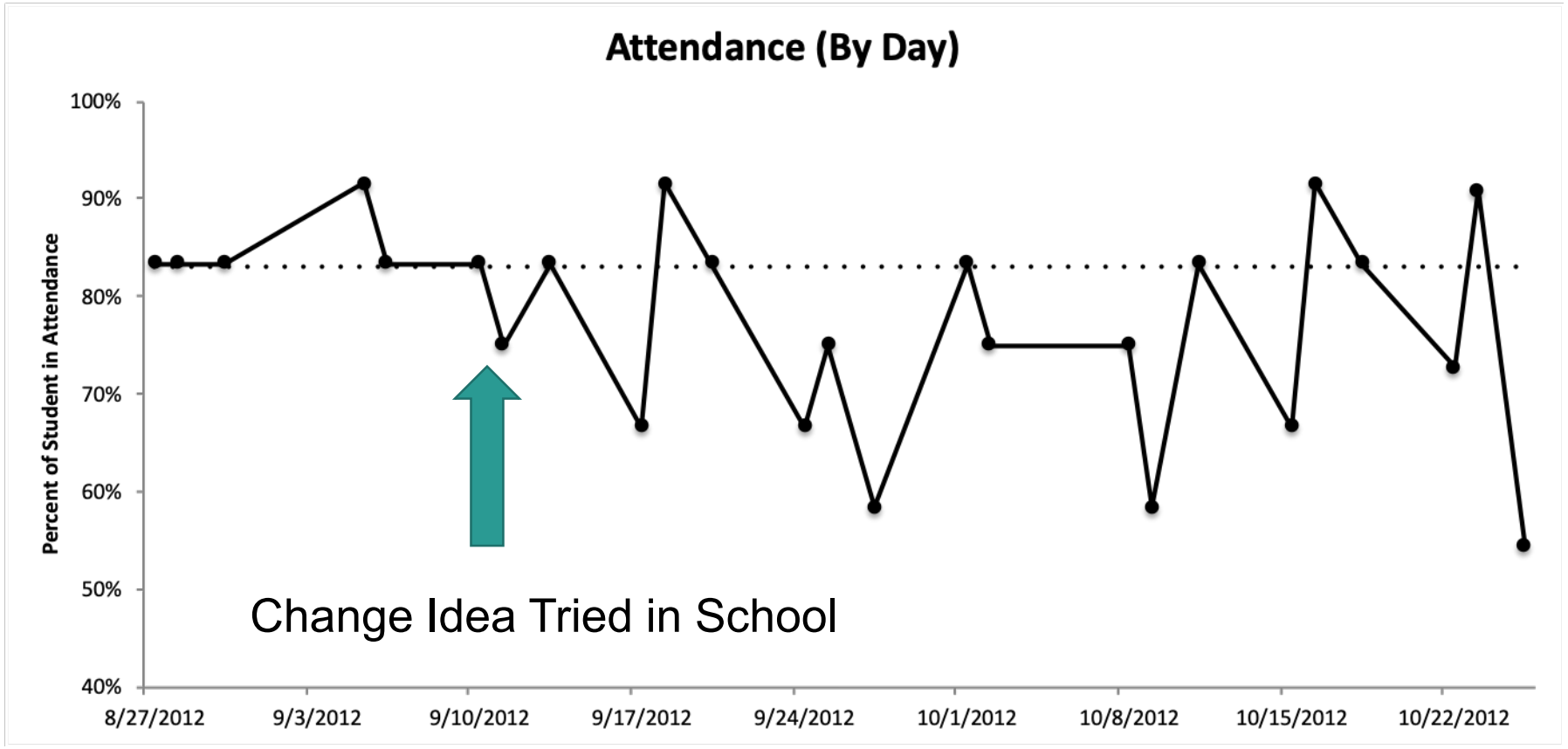
Example 2: Analysis

- 1 shift (Rule 1)
- 2 trends (Rule 2)
- 3 runs (Rule 3)
- No astronomical points (Rule 4)

Total Number of Data Pts	Lower Limit	Upper Limit
11	3	9
12	3	10
13	4	11

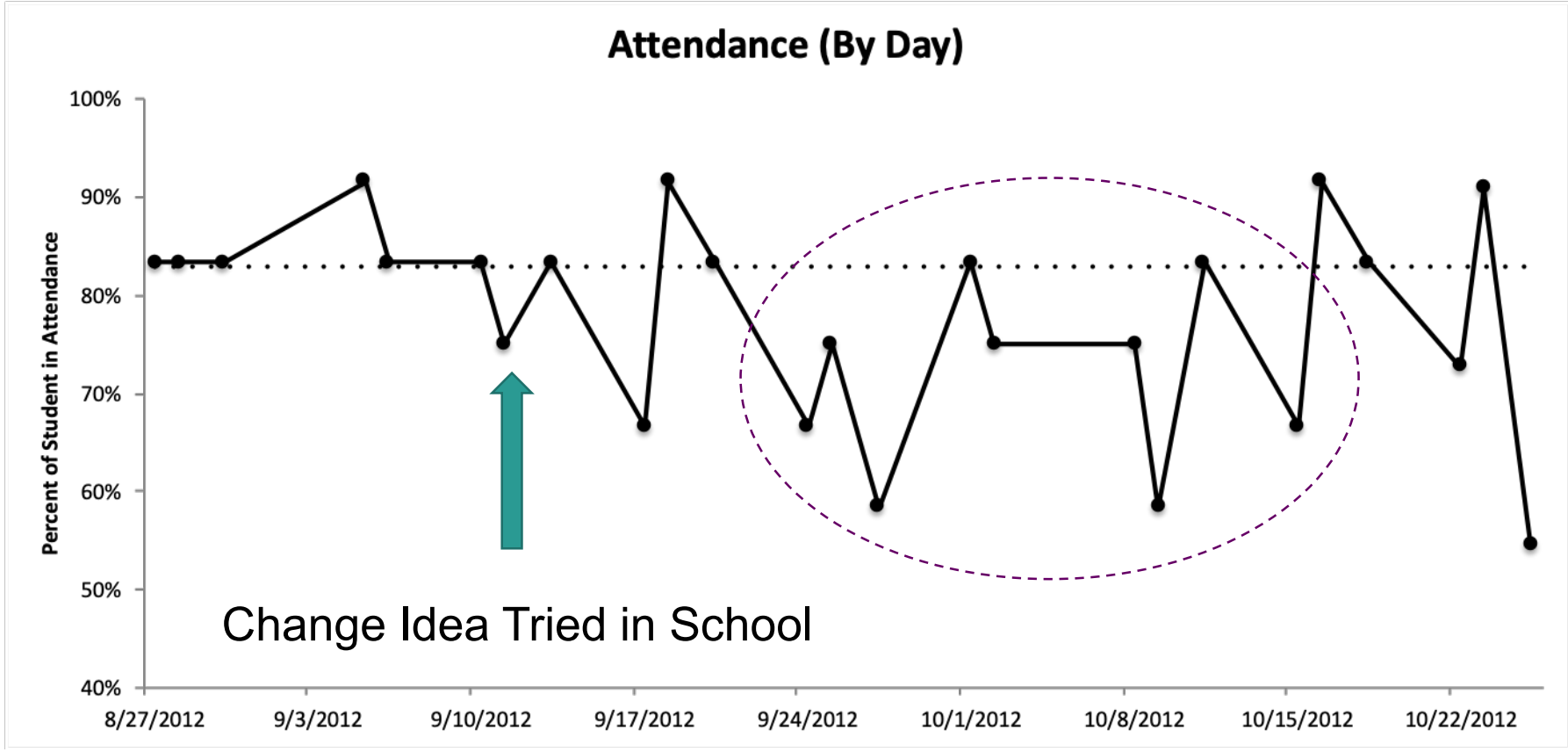


Example 3: Do Any Rules Apply?

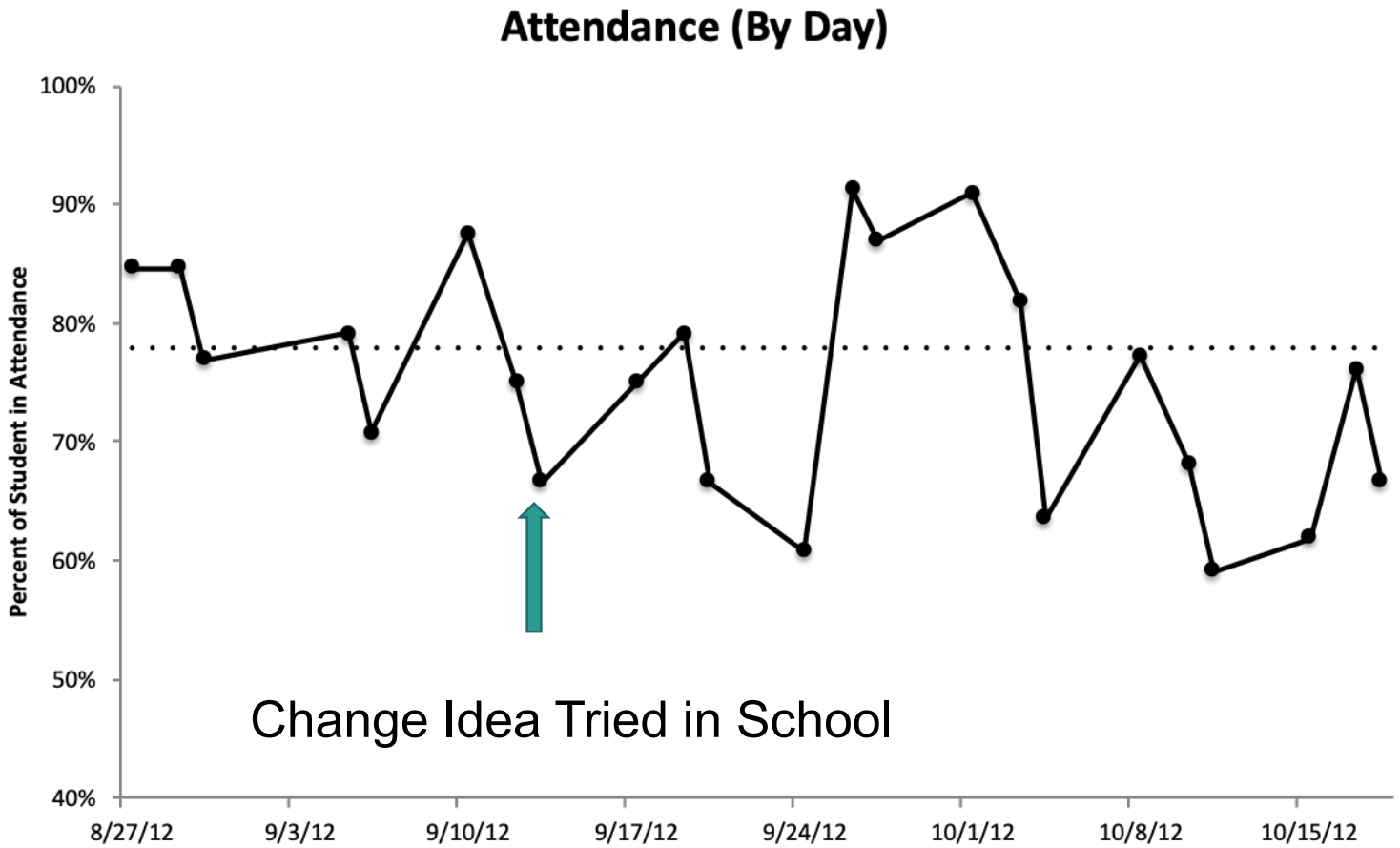


Example 3: Analysis

- 1 shift (Rule 1)
- No trends (Rule 2)
- 11 runs (Rule 3)
- No astronomical points (Rule 4)

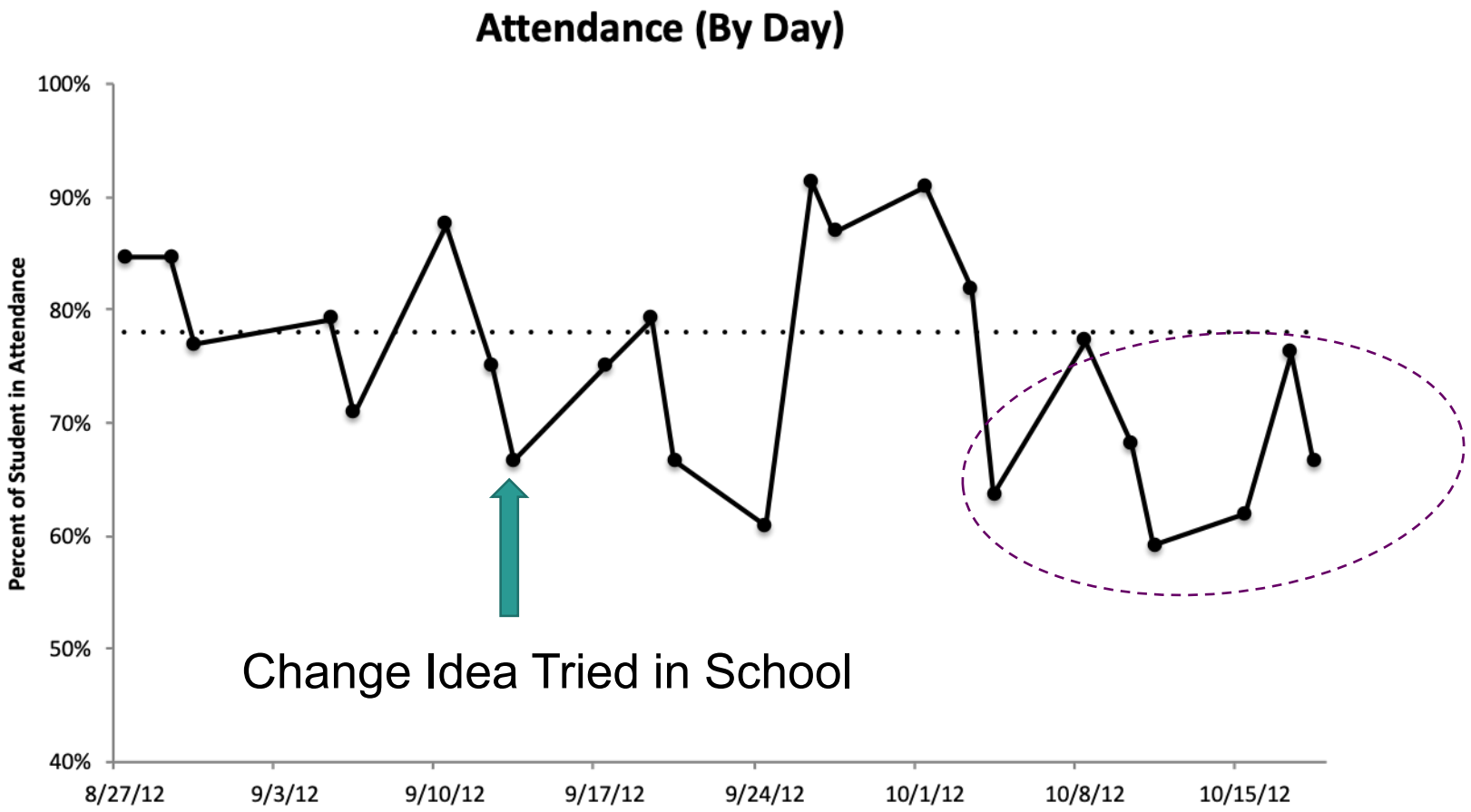


Example 4: Do Any Rules Apply?



Example 4: Analysis

- 1 shift (Rule 1)
- No trends (Rule 2)
- 10 runs (Rule 3)
- No astronomical points (Rule 4)



Practicing When to Use Run Charts

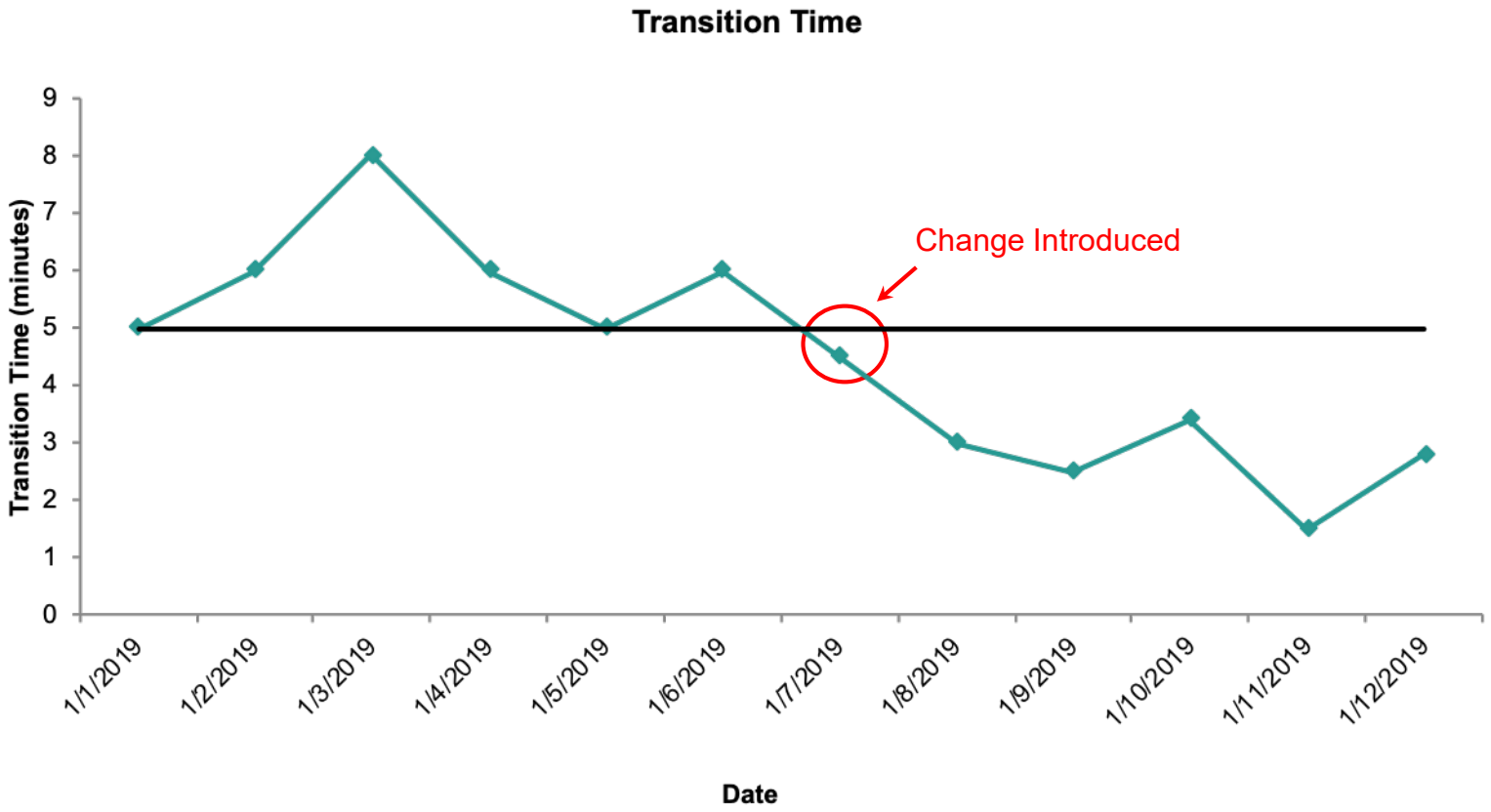
Scenario One

A teacher finds that his students are spending too much time on classroom transitions. One week later, he begins to positively reinforce students who transition quickly. The teacher wants to assess if this change is effectively decreasing transition time and thus continues to collect transition time data.

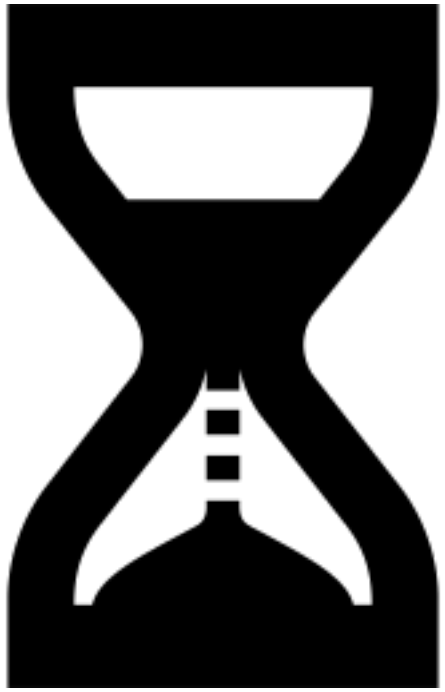
Is a run chart an appropriate tool? Why or why not?

Use a Run Chart!

A run chart helps the teacher assess if the change was an improvement. Having introduced the change on day 7, he notices a shift in which the transition time is below the median for 6 observations in a row.



Scenario 2

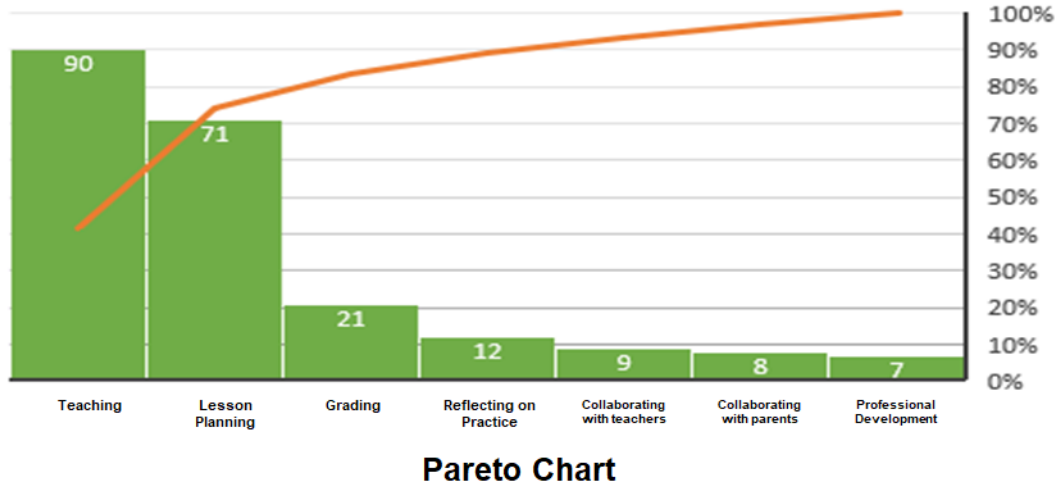


A teacher is curious how much time she spends on different aspects of her job (teaching, lesson planning, grading, etc.) and wants to determine how much of her work day she spends engaging in each activity.

Is a run chart appropriate? Why or why not?

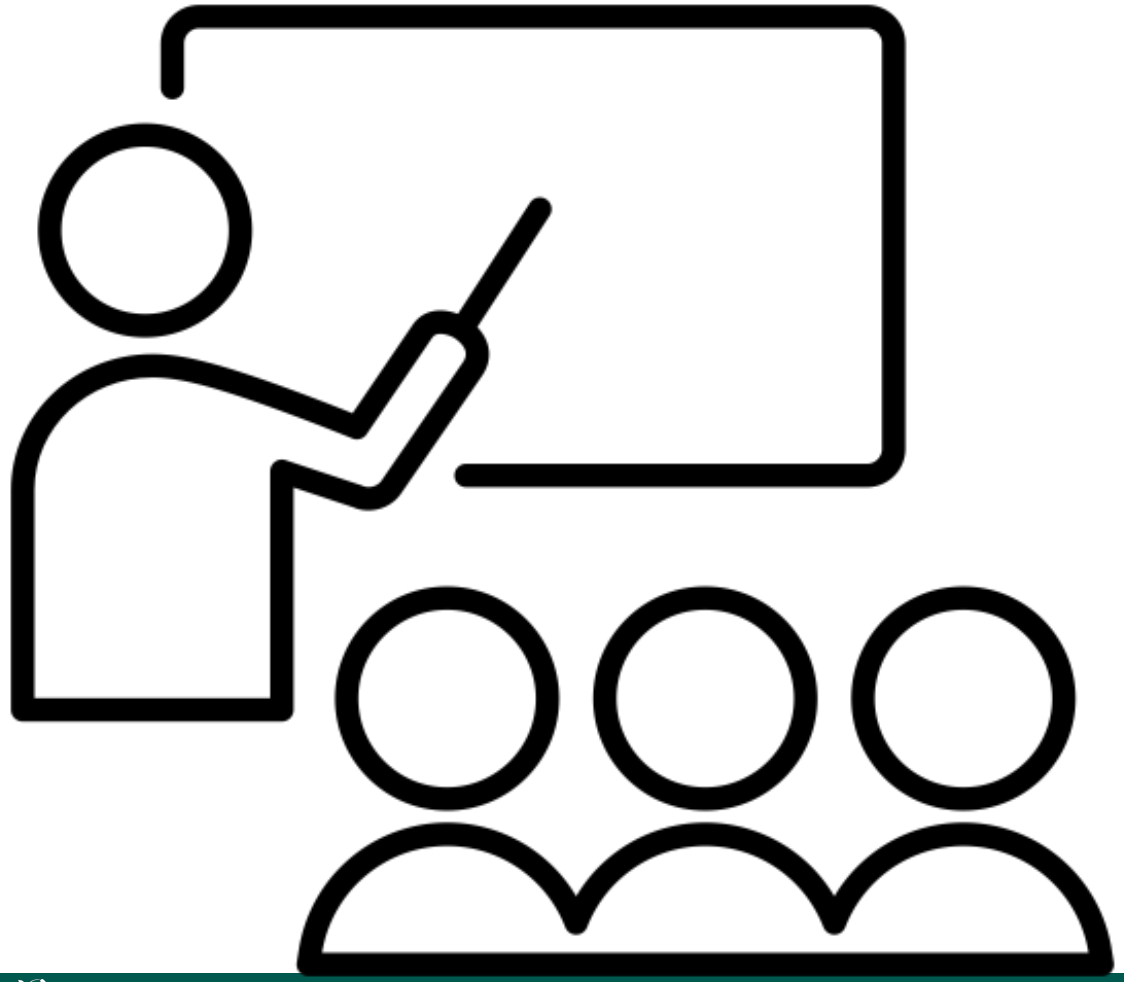
Don’t Use a Run Chart!

The teacher is not measuring a process over time so a run chart should not be used. In this case, a pareto chart is more appropriate.



Pareto Chart

Closing



A run chart is one tool for understanding data over time.

It helps improvers investigate if a change is an improvement.

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