Percentiles & Z-Scores

- Lesson 2.1 -
Wilt - 1960’s

Jordan - 1990’s

LeBron - 2010’s

Paul Vathis, AP Images

Skew The Script
skewthescript.org
Today’s Key Analysis
Who was the G.O.A.T. at scoring?
Lesson 2.1
Guided Notes

Handout: skewthescript.org/2-1
Topics

1. Percentiles
2. Cumulative Relative Frequency
3. Standardized Scores (Z-Scores)
Topics

1. Percentiles

2. Cumulative Relative Frequency

3. Standardized Scores (Z-Scores)
Who did better on their SAT?

Mr. Young-Saver
Statistician, Math Teacher

VS.

Guy Fieri
Chef, Mayor of Flavortown
Who did better on their SAT?

Mr. Young-Saver
Statistician, Math Teacher

1050 out of 1600 SAT
Who did better on their SAT?

They don’t offer the SAT in Flavortown, USA!

Guy Fieri
Chef, Mayor of Flavortown
Who did better on their SAT?

They don’t offer the SAT in Flavortown, USA!

Mr. Fieri took the ACT

Guy Fieri
Chef, Mayor of Flavortown
Who did better on their SAT?

ACT 23 out of 36

Guy Fieri
Chef, Mayor of Flavortown
Who should Flavortown College select?
Who should Flavortown College select?

SAT: 1050

VS.

ACT: 23
Who should Flavortown College select?

SAT: 1050
1050/1600 = 66%

ACT: 23
23/36 = 64%
Who should Flavortown College select?

It’s not that simple!

The tests use different scales and scoring systems.

SAT: 1050
1050/1600 = 66%

ACT: 23
23/36 = 64%
Who should Flavortown College select?

It’s not that simple!
The tests use different scales and scoring systems.

How to compare?

SAT: 1050
1050/1600 = 66%

ACT: 23
23/36 = 64%
Percentiles

**Percentile**: the percent of data *less than or equal to* a certain data value.
Percentiles

**Percentile**: the percent of data **less than or equal to** a certain data value.

**Note**: Sometimes it’s just “less than,” but in AP Stats it’s “less than or equal to”
Percentiles

**Percentile**: the percent of data less than or equal to a certain data value.

Salaries at a company (thousands of $)

29, 32, 34, 34, 34, 34, 35, 35, 39, 43, 67, 185
Percentiles

**Percentile**: the percent of data **less than or equal to** a certain data value.

**Question**: At what percentile is the person who makes a salary of $43,000?

29, 32, 34, 34, 34, 34, 35, 35, 39, **43**, 67, 185
Percentiles

*Percentile:* the percent of data less than or equal to a certain data value.

**Question:** At what percentile is the person who makes a salary of $43,000?

29, 32, 34, 34, 34, 34, 35, 35, 39, 43, 67, 185

“less than or equal to”
Percentiles

**Percentile**: the percent of data **less than or equal to** a certain data value.

**Question**: At what percentile is the person who makes a salary of $43,000?

10 salaries at or below $43,000
Percentiles

**Percentile**: the percent of data **less than or equal to** a certain data value.

**Question**: At what percentile is the person who makes a salary of $43,000?

29, 32, 34, 34, 34, 34, 35, 35, 39, 43, 67, 185

\[
\frac{10}{12} \approx 83\%
\]
Percentiles

Percentile: the percent of data less than or equal to a certain data value.

**Question:** At what percentile is the person who makes a salary of $43,000?

29, 32, 34, 34, 34, 34, 35, 35, 39, 43, 67, 185

10 / 12 ≈ 83% → The salary of $43,000 is at the 83rd percentile of salaries.
Percentiles and Boxplots

For large datasets...
Percentiles and Boxplots

For large datasets...

Q1 is at the 25\textsuperscript{th} percentile.
Percentiles and Boxplots

For large datasets...

The median (Q2) is at the 50\textsuperscript{th} percentile.
Percentiles and Boxplots

For large datasets...

Q3 is at the 75\textsuperscript{th} percentile.
Who should Flavortown College select?

SAT: 1050

VS.

ACT: 23
Who should Flavortown College select?

What percent of people did each test-taker outscore?

SAT: 1050 vs. ACT: 23
<table>
<thead>
<tr>
<th>SAT</th>
<th>Percentile</th>
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</thead>
<tbody>
<tr>
<td>1600</td>
<td>100%</td>
</tr>
<tr>
<td>1550</td>
<td>99.3%</td>
</tr>
<tr>
<td>1500</td>
<td>98%</td>
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<tr>
<td>1450</td>
<td>95%</td>
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<table>
<thead>
<tr>
<th>ACT</th>
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From 2019-2020 school year test reports
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<th>ACT</th>
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<tr>
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<tr>
<td>600</td>
<td>1%</td>
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</tbody>
</table>

From 2019-2020 school year test reports.
I tied or outscored 45% of SAT test takers

From 2019-2020 school year test reports

Mr. Fieri tied or outscored 69% of test takers
Who should Flavortown College select?

VS.

SAT: 1050

ACT: 23
Who should Flavortown College select?

SAT: 1050
45th Percentile

VS.

ACT: 23
69th Percentile
Who should Flavortown College select?

SAT: 1050
45th Percentile

ACT: 23
69th Percentile

Guy Fieri’s score is the more impressive one.
Topics

1. Percentiles
2. Cumulative Relative Frequency
3. Standardized Scores (Z-Scores)
Cumulative Relative Frequency Charts

ACT Scores

Cumulative Frequency

10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36

Cumulative Frequency

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Cumulative Relative Frequency Charts

*scary*

Cumulative Frequency

ACT Scores
Cumulative Relative Frequency Charts = Percentile
Cumulative Relative Frequency Charts

= Percentile

Cumulative Frequency

ACT Scores
Cumulative Relative Frequency Charts = Percentile

ACT Scores
Cumulative Relative Frequency Charts

Percentile

ACT Scores
Cumulative Relative Frequency Charts

Is 18 a good ACT score?
Cumulative Relative Frequency Charts

Is 18 a good ACT score?
Cumulative Relative Frequency Charts

Is 18 a good ACT score?
Cumulative Relative Frequency Charts

Is 18 a good ACT score?

18

40%
Cumulative Relative Frequency Charts

Is 18 a good ACT score? → 40th percentile
Is 18 a good ACT score? → 40th percentile

A score of 18 is at or above 40% of ACT test takers.
Cumulative Relative Frequency Charts

Is 18 a good ACT score? → 40th percentile

A score of 18 is at or above 40% of ACT test takers. It’s an ok score.
Cumulative Relative Frequency Charts

To be in the top quartile, what score do you need?

75%
Cumulative Relative Frequency Charts

To be in the top quartile, what score do you need?

75%
Cumulative Relative Frequency Charts

To be in the top quartile, what score do you need?

75%

ACT Scores

24
To be in the top quartile, what score do you need?

You would need a score of 24 or higher to be in the top quartile.
To be in the top quartile, what score do you need?

You would need a score of 24 or higher to be in the top quartile.
Topics

1. Percentiles
2. Cumulative Relative Frequency
3. Standardized Scores (Z-Scores)
Z-Scores (Standardized Score)

Z-Scores: measures how many standard deviations a data point is above/below the mean.
Z-Scores (Standardized Score)

Z-Scores: measures how many standard deviations a data point is above/below the mean.

\[
Z = \frac{\text{data point} - \text{mean}}{\text{standard deviation}}
\]

\[
Z = \frac{x_i - \mu}{\sigma}
\]
Who is the best scorer?

Wilt - 1960’s  
Jordan - 1990’s  
LeBron - 2010’s

All NBA stats used in this lesson were made possible by the data compiled in this NBA Kaggle database: kaggle.com/drgilermo/nba-players-stats
Who is the best scorer?

- Wilt - 60’s: 30.1 PPG
- Jordan - 90’s: 30.1 PPG
- LeBron - 2010’s: 27.1 PPG

Note: All NBA data in this lesson is from 2020 and prior.
Who is the best relative to their time?

Wilt - 60’s

Jordan - 90’s

LeBron - 2010’s

30.1 PPG  
30.1 PPG  
27.1 PPG

Note: All NBA data in this lesson is from 2020 and prior
Who is the best relative to their time?

Wilt - 60’s

30.1 PPG

60’s NBA: $\mu = 10.8$ ppg

Jordan - 90’s

30.1 PPG

90’s NBA: $\mu = 8.7$ ppg

LeBron - 2010’s

27.1 PPG

2010’s NBA: $\mu = 8.4$ ppg

**Note:** All NBA data in this lesson is from 2020 and prior.
Who is the best relative to their time?

<table>
<thead>
<tr>
<th>Year</th>
<th>Player</th>
<th>Points Per Game (PPG)</th>
<th>NBA Mean (μ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>60's</td>
<td>Wilt</td>
<td>30.1 PPG</td>
<td>μ = 10.8 ppg</td>
</tr>
<tr>
<td>90's</td>
<td>Jordan</td>
<td>30.1 PPG</td>
<td>μ = 8.7 ppg</td>
</tr>
<tr>
<td>2010's</td>
<td>LeBron</td>
<td>27.1 PPG</td>
<td>μ = 8.4 ppg</td>
</tr>
</tbody>
</table>

**Diff:**
- Wilt vs. 60's NBA: 30.1 – 10.8 = **19.3**
- Jordan vs. 90's NBA: 30.1 – 8.7 = **21.4**
- LeBron vs. 2010's NBA: 27.1 – 8.4 = **18.7**
Who is the best relative to their time?

Wilt - 60’s

30.1 PPG

60’s NBA: $\mu = 10.8$ ppg

$30.1 - 10.8 = 19.3$

Jordan - 90’s

30.1 PPG

90’s NBA: $\mu = 8.7$ ppg

$30.1 - 8.7 = 21.4$

LeBron - 2010’s

27.1 PPG

2010’s NBA: $\mu = 8.4$ ppg

$27.1 - 8.4 = 18.7$

Diff:

- Wilt: 19.3
- Jordan: 21.4
- LeBron: 18.7
What about variability?

A: Low Variability
\[ \mu = 10 \text{ PPG} \]
\[ \sigma = 2 \text{ PPG} \]

B: High Variability
\[ \sigma = 4 \text{ PPG} \]
What about variability?

A: Low Variability

\[ \mu = 10 \text{ PPG} \]

\[ \sigma = 2 \text{ PPG} \]

B: High Variability

\[ \sigma = 4 \text{ PPG} \]
What about variability?

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What about variability?

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\[ \sigma = 2 \text{ PPG} \]

B: High Variability

\[ \sigma = 4 \text{ PPG} \]
What about variability?

**A: Low Variability**
- \( \mu = 10 \) PPG
- \( \sigma = 2 \) PPG

**B: High Variability**
- \( \sigma = 4 \) PPG

\[ \mu = \text{10 PPG} \]
\[ \sigma = \text{2 PPG} \]
\[ \sigma = \text{4 PPG} \]
What about variability?

A: Low Variability
\[ \mu = 10 \text{ PPG} \]
\[ \sigma = 2 \text{ PPG} \]

B: High Variability
\[ \sigma = 4 \text{ PPG} \]
What about variability?

A: Low Variability

\[ \mu = 10 \text{ PPG} \]

\[ \sigma = 2 \text{ PPG} \]

I’m 2\( \sigma \) above the mean!

B: High Variability

\[ \mu = 10 \text{ PPG} \]

\[ \sigma = 4 \text{ PPG} \]

I’m 1\( \sigma \) above the mean.

14 PPG
What about variability?

A: Low Variability

\[ \mu = 10 \text{ PPG} \]

\[ \sigma = 2 \text{ PPG} \]

I’m \(2\sigma\) above the mean!

Only a few players better than me

B: High Variability

\[ \mu = 10 \text{ PPG} \]

\[ \sigma = 4 \text{ PPG} \]

I’m \(1\sigma\) above the mean

A good number of players better than me

\[ \mu = 10 \text{ PPG} \]

\[ \sigma = 2 \text{ PPG} \]

\[ \sigma = 4 \text{ PPG} \]
Standardization

A point’s location in the distribution depends on **both** distance from the **center** and the distribution’s **spread** or variation.
Standardized: Who Was Best?

Wilt - 60’s  
30.1 – 10.8 =  
Diff: 19.3 ppg

Jordan - 90’s  
30.1 – 8.7 =  
21.4 ppg

LeBron - 2010’s  
27.1 – 8.4 =  
18.7 ppg
Standardized: Who Was Best?

Wilt - 60’s

30.1 – 10.8 = 19.3 ppg

Diff: 7.0 ppg

Jordan - 90’s

30.1 – 8.7 = 21.4 ppg

35.9 ppg

LeBron - 2010’s

27.1 – 8.4 = 18.7 ppg

21.6 ppg
Standardized: Who Was Best?

Wilt - 60’s

30.1 – 10.8 = 19.3 ppg

Diff: \( (Z) \)
\( (\sigma) \) 7.0 ppg

Jordan - 90’s

30.1 – 8.7 = 21.4 ppg

30.1 – 8.7 = 21.4 ppg

LeBron - 2010’s

27.1 – 8.4 = 18.7 ppg

27.1 – 8.4 = 18.7 ppg

Z-score: The number of standard deviations away from the mean
Standardized: Who Was Best?

Wilt - 60’s

\[
30.1 - 10.8 = 19.3 \text{ ppg}
\]

\[
\text{Diff:} \quad \frac{19.3}{7.0} \text{ ppg} \quad (\sigma)
\]

Jordan - 90’s

\[
30.1 - 8.7 = 21.4 \text{ ppg}
\]

\[
\frac{21.4}{5.9} \text{ ppg}
\]

LeBron - 2010’s

\[
27.1 - 8.4 = 18.7 \text{ ppg}
\]

\[
\frac{18.7}{5.5} \text{ ppg}
\]

**Z-score:** The number of standard deviations away from the mean
Standardized: Who Was Best?

Wilt - 60’s

30.1 – 10.8 = 19.3 ppg

\[ \frac{19.3}{7.0} = 2.8 \]

Jordan - 90’s

30.1 – 8.7 = 21.4 ppg

\[ \frac{21.4}{5.9} = 3.6 \]

LeBron - 2010’s

27.1 – 8.4 = 18.7 ppg

\[ \frac{18.7}{5.5} = 3.4 \]

Z-score: The number of standard deviations away from the mean
Standardized: Who Was Best?

Wilt - 60’s

\[ \frac{30.1 - 10.8}{7.0} = 2.8 \]

Jordan - 90’s

\[ \frac{30.1 - 8.7}{5.9} = 3.6 \]

LeBron - 2010’s

\[ \frac{27.1 - 8.4}{5.5} = 3.4 \]

Data – Mean
Standard Dev
G.O.A.T

Wilt - 60’s

30.1 – 10.8
7.0
(Z) = 2.8

Jordan - 90’s

30.1 – 8.7
5.9
(Z) = 3.6

LeBron - 2010’s

27.1 – 8.4
5.5
(Z) = 3.4

Data – Mean
Standard Dev
MJ’s PPG was 3.6 standard deviations above the mean for his era, making him the most unusually high scorer.
What about a not-so-great player?

2009 Season: played 44 minutes total

Adam Morrison, pictured where he spent most of his time with the Lakers: on the bench.
What about a not-so-great player?

Adam Morrison, pictured where he spent most of his time with the Lakers: on the bench.

2009 Season:
played 44 minutes total

2,999 min

2,960 min
What about a not-so-great player?

2009 Season: played 44 minutes total

Adam Morrison, pictured where he spent most of his time with the Lakers: on the bench.

2,999 min

2,960 min
What about a not-so-great player?
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What about a not-so-great player?
What about a not-so-great player?
What about a not-so-great player?

While with the Lakers, he averaged **2.2 PPG**. (League: $\mu = 8.4$, $\sigma = 5.5$)

**Adam Morrison**, pictured where he spent most of his time with the Lakers: on the bench.
What about a not-so-great player?

While with the Lakers, he averaged **2.2 PPG**. (League: $\mu = 8.4$, $\sigma = 5.5$)

$$z = \frac{\text{data point} - \text{mean}}{\text{standard deviation}}$$

**Adam Morrison**, pictured where he spent most of his time with the Lakers: on the bench.
What about a not-so-great player?

While with the Lakers, he averaged **2.2 PPG**. (League: $\mu = 8.4$, $\sigma = 5.5$)

$$z = \frac{\text{data point} - \text{mean}}{\text{standard deviation}}$$

$$z = \frac{2.2 - 8.4}{5.5}$$

Adam Morrison, pictured where he spent most of his time with the Lakers: on the bench.
What about a not-so-great player?

Adam Morrison, pictured where he spent most of his time with the Lakers: on the bench.

While with the Lakers, he averaged **2.2 PPG.** (League: $\mu = 8.4$, $\sigma = 5.5$)

$$z = \frac{\text{data point} - \text{mean}}{\text{standard deviation}}$$

$$z = \frac{2.2 - 8.4}{5.5} = -1.1$$
What about a not-so-great player?

Adam Morrison’s scoring rate was 1.1 standard deviations **below** the league **average** in his era.

While with the Lakers, he averaged **2.2 PPG**. (League: $\mu = 8.4$, $\sigma = 5.5$)

$$z = \frac{\text{data point} - \text{mean}}{\text{standard deviation}}$$

$$z = \frac{2.2 - 8.4}{5.5} = -1.1$$
Positive/Negative Z-Scores

2.2 PPG
\[ z = -1.1 \]

27.1 PPG
\[ z = 3.4 \]
Positive/Negative Z-Scores

\[ z = \frac{\text{data point} - \text{mean}}{\text{standard deviation}} \]

2.2 PPG

\[ z = -1.1 \]

27.1 PPG

\[ z = 3.4 \]

- data > mean → positive
- data < mean → negative
Positive/Negative Z-Scores

Positive Z-Score: The number of standard devs above the mean.

Negative Z-Score: The number of standard devs below the mean.

\[
\begin{align*}
\text{2.2 PPG} & \quad z = -1.1 \\
\text{27.1 PPG} & \quad z = 3.4
\end{align*}
\]

\[
z = \frac{\text{data point} - \text{mean}}{\text{standard deviation}}
\]

- data > mean $\rightarrow$ positive
- data < mean $\rightarrow$ negative
It’s all about the bling.

Pau Gasol

Kobe Bryant
It’s all about the bling.

Pau Gasol

Kobe Bryant

2009
It’s all about the bling.

Pau Gasol  

Kobe Bryant

2009  

2010
It’s all about the bling.

Pau Gasol

Kobe Bryant

Adam Morrison

2009

2010
It’s all about the bling.

*has more championship rings than...*

Adam Morrison

2.2 PPG

2009  2010
It’s all about the bling. *has more championship rings than...*

Adam Morrison

2.2 PPG

2009 2010

Allen Iverson

26.7 PPG
It’s all about the bling.

has more championship rings than...

Adam Morrison

2009 2010

2.2 PPG

Allen Iverson 26.7 PPG

Russell Westbrook 23.2 PPG
It’s all about the bling.

has more championship rings than...

Adam Morrison
2.2 PPG
2009
2010

Allen Iverson
26.7 PPG

Russell Westbrook
23.2 PPG

Steve Nash
14.3 PPG

Photo: opencourt-basketball.com
It’s all about the bling.

Has more championship rings than...

Adam Morrison

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14.3 PPG

Harden

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- 2.2 PPG
- 2009
- 2010

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Barkley 22.1 PGG
It’s all about the bling.

has more championship rings than...

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2.2 PPG

Jerry West
27.0 PPG

Russell Westbrook
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Photo: opencourt-basketball.com
It’s all about the bling.

has more championship rings than...

COMBINED

Adam Morrison

Jerry West

Russell Westbrook

Steve Nash

Ewing

Allen Iverson

Chris Paul

Barkley

Harden

Malone

2.2 PPG

27.0 PPG

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21.0 PPG

25.1 PPG

21.0 PPG
It’s all about the bling.

G.O.A.T?

Has more championship rings than...

**COMBINED**

Adam Morrison

2.2 PPG

Jerry West

27.0 PPG

Russell Westbrook

23.2 PPG

Harden

25.1 PPG

Allen Iverson

25.0 PPG

Malone

21.0 PPG

Barkley

22.1 PPG

Ewing

21.0 PPG

Chris Paul

18.5 PPG

Steve Nash

23.2 PPG

Combining all these greats, who is the greatest of all time (G.O.A.T.) in basketball?
Lesson 2.1 Discussion
• Jordan scored the most (relatively)
• Jordan scored the most (relatively)
• Is it because he shot the most?
Wilt: 22.5
Jordan: 22.9
LeBron: 19.6

Shots per game
Wilt  |  Jordan  |  LeBron

<table>
<thead>
<tr>
<th></th>
<th>Shots per game</th>
<th></th>
<th>% shots made</th>
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<tbody>
<tr>
<td>22.5</td>
<td>22.9</td>
<td>19.6</td>
<td></td>
</tr>
<tr>
<td>54.0%</td>
<td>49.7%</td>
<td>50.4%</td>
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</tr>
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</table>

Paul Vathis, AP Images
<table>
<thead>
<tr>
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<th>Jordan</th>
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**Discussion:** Is Jordan still the G.O.A.T at scoring? What other stats may be helpful in determining who was the best?
Lesson 2.1 Practice