# Balls and boxes

During this lesson, students collect the bounce height of various balls and use the data to produce parallel box plots. They make a claim about the data and support their claim using evidence.

## Visible learning

### Learning intention

* To be able to compare box plots to make informed decisions.

### Success criteria

* I can compare box plots by referencing the median.
* I can compare box plots by referencing the interquartile range.
* I can compare box plots by referencing the shape of the data.

### Syllabus outcomes

A student:

* develops understanding and fluency in mathematics through exploring and connecting mathematical concepts, choosing and applying mathematical techniques to solve problems, and communicating their thinking and reasoning coherently and clearly **MAO-WM-01**
* compares and analyses datasets using summary statistics and graphical representations **MA5-DAT-C-01**

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## Activity structure

Please use the associated PowerPoint Balls and boxes to display images in this lesson.

### Warm up

1. Distribute Appendix A ‘Pass it on’, cut into cards and placed face down, to each pair of students. This Appendix shows a range of dot plots.
2. Share the instructions of the game ‘Pass it on’ verbally. They can be found below or in Appendix A ‘Pass it on’.

In pairs, decide who will be Player 1 and Player 2.

Player 1 should select a card.

Player 1 is to describe the graph on their card for Person 2 to draw.

Once they have finished, they should compare the drawing with the original graph.

The pairs should then swap roles and repeat.

Students should complete 2 rounds of this activity so that each student has a chance to describe a graph twice.

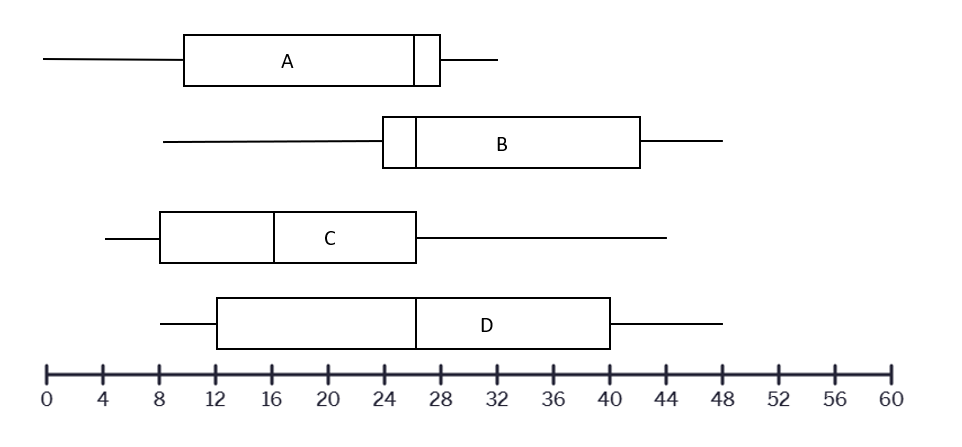
1. Start a class discussion by asking students which graphs they found the easiest and hardest to describe and why.

Use slides 3–6 of the *Balls and boxes* PowerPoint during the discussion to highlight and reinforce responses from students who used the language of positively or negatively skewed, symmetrical, unimodal, bimodal or trimodal.

### Launch

1. Display slide 8 of the PowerPoint *Balls and boxes*. In a Think-Pair-Share ([bit.ly/thinkpairsharestrategy](https://bit.ly/thinkpairsharestrategy)), ask students which one does not belong ([bit.ly/wodb](https://bit.ly/wodb)).

Figure 1: Which one doesn't belong?



The data is set up such that one would not belong if students focused on either the difference in median, mode and mean. This should be drawn out during the share.

### Explore

1. Display different types of balls (see options from the equipment list below) and ask students to make 2 predictions using the following prompts.

* Which ball do you think will bounce the highest when dropped from one metre?
* Which ball do you think will be the most consistent (bounces the same each time) when repeatedly dropped from one metre?

1. Facilitate a whole-class discussion by randomly choosing students who picked different types of balls to explain their reasoning.
2. Students will now gather evidence by completing the following activity.

#### Equipment

* Different types of balls (golf ball, basketball, hand ball, tennis ball, ping pong ball). Teachers can provide each group with different types of balls or have a bucket with random balls for the students to come and collect after each testing.
* Tape measures (1 per group)
* Chalk (1 per group)

#### Method

1. Assign random groups of 3 ([bit.ly/visiblegroups](https://bit.ly/visiblegroups)) and provide each group with the equipment listed above.

Students should be provided with a minimum of 3 different types of balls.

Ideally, each group should have a different ball but if this is not possible allow groups to use the same ball type and collate the data at the end of the experiment.

1. Take students to an area with a hard consistent floor surface, against a wall.
2. Students are to fix the tape measure to the wall, marking where one metre is.
3. One student drops their ball from the one metre mark whilst the other team members watch closely and record how far the ball bounces back.

This measurement will be difficult to get accurate, so it is suggested that 2 team members record their answers and students find the average of these measurements. Students should be encouraged to discuss how they will perform the experiment, where they are measuring from on the ball (the top of the ball or the bottom of the ball) and how they are going to maintain consistency in their measurements.

1. Repeat the process until they have 15 measurements for each ball.
2. Back in the classroom, students need to record their results on vertical non-permanent surfaces ([bit.ly/VNPSstrategy](https://bit.ly/VNPSstrategy)).

This could also be done using a spreadsheet.

1. Have students find the 5-number summary for each ball they bounced and construct a box plot for their data set.

The aim of this lesson is to compare box plots, so the data could be entered into a spreadsheet and the box plots constructed digitally.

1. Have groups write 3 things that are similar about 2 or more box plots and 3 things that are different.
2. Students are to do a gallery walk ([bit.ly/DLSgallerywalk](https://bit.ly/DLSgallerywalk)) of the graphs providing feedback on the similarities and differences using the Two stars and a wish method ([bit.ly/2starwish](https://bit.ly/2starwish)) of peer feedback.

### Summarise

1. Use slide 10 from the *Balls and boxes* PowerPoint to model how students can make a claim based on the data gathered.

A claim is astatement or conclusion that answers the original question or it's the point you're trying to make or prove.

1. Have students write their own claim based on the data. This may be the same or different from their prediction.
2. Ask students what evidence they can use to support their claim and to construct a logical argument.

Students should recognise that the data collected in the investigation would be appropriate and sufficient to support their claim.

1. Ask students what components of the box plots they could compare to form this argument.

Students should mention range, interquartile range, median or even skew.

1. Use slides 11 to 19 of the *Balls and boxes* PowerPoint to explicitly teach 4 specific talking points and sentence starters that students could use to provide evidence for their claim.

An outlier in a box plot is a stand-alone point outside the minimum and maximum. It is represented as a small cross.

1. Students will now use the discussed sentence starters to write evidence to support their claim.

### Apply

1. Establish new random groups of 3 and distribute a copy of Appendix B ‘More golf data’ to each group.
2. Have each group analyse the data to support or dismiss the claim.
3. Allow time for students to view each group’s work by performing a gallery walk. Students may like to provide each group with feedback using the peer feedback strategy ‘Two stars and a wish’.

## Assessment and differentiation

### Suggested opportunities for differentiation

**Explore**

* If students have used the same ball type but different balls, a separate comparison could be done of this data.
* Students may copy other student’s box plots if there is not enough time to draw all of them.

**Summarise**

* Provide students with a worksheet that has the sentence starters written as cloze passages for students to fill in the gaps with their own observations.
* Allow students to do voice recordings explaining the evidence for their claim using the sentence starter prompts.

**Apply**

* Print the graphs in colour on A4 paper to hand out to each group. This allows students to see greater details from the graphs.
* Ask students to use both sets of data to make a claim about the type of clubs which may be more suitable at the golf courses.

### Suggested opportunities for assessment

**Explore**

* When placed in groups of 3, students provide and receive peer feedback on their understanding of interpreting collected data as evidence to substantiate a claim.

**Summarise**

* Students will demonstrate their Working mathematically skills in discussions and justifications for their claim. Teachers can use the suggested differentiation options to collect students’ justifications for their claims to formatively assess their use of comparative mathematical language to communicate their arguments.

**Apply**

* Monitor responses in class discussions to check for student understanding of box plots and how they are compared.

## Appendix A

### Pass it on

**Rules**

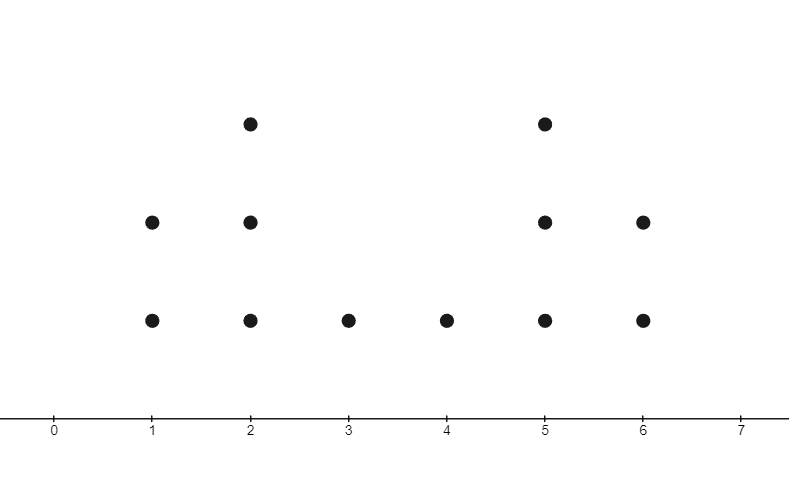
1. In pairs, decide who will be Player 1 and Player 2.
2. Player 1 should select a card.
3. Player 1 is to describe the graph on their card for Person 2 to draw.
4. Once they have finished, they should compare the drawing with the original graph.
5. The pairs should then swap roles and repeat.

#### Graphs

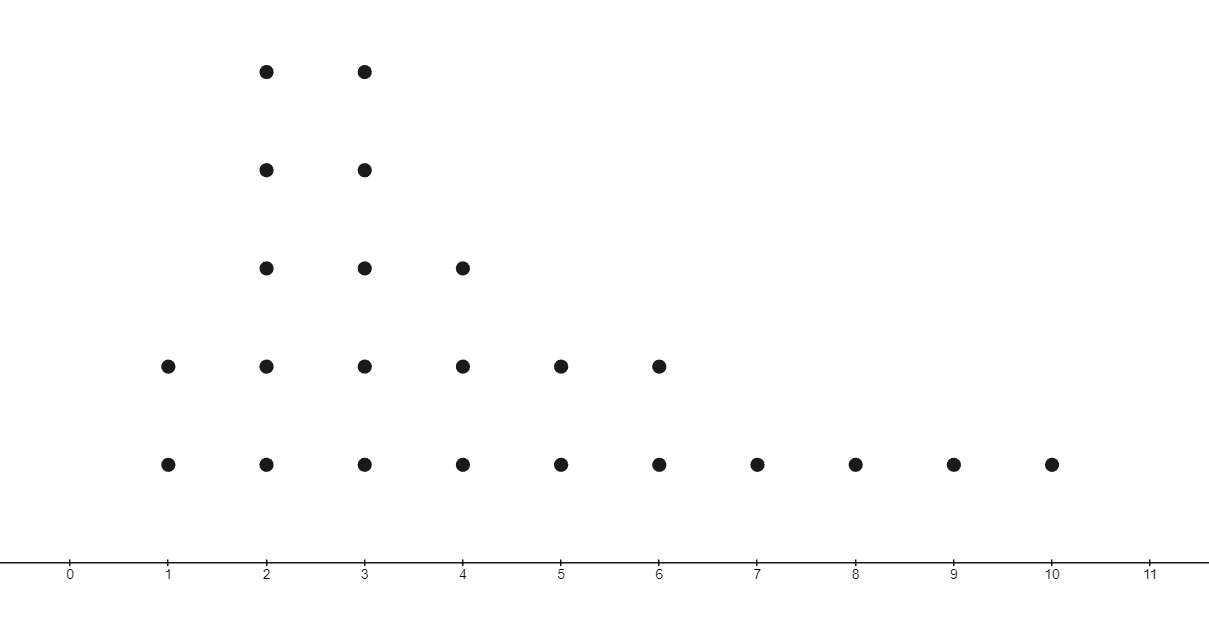
##### Dot plot 1

#### A dot plot between the numbers 0 and 6. One occurs once, 2 occurs twice, 3 occurs 4 times, 4 occurs twice, 5 occurs once.

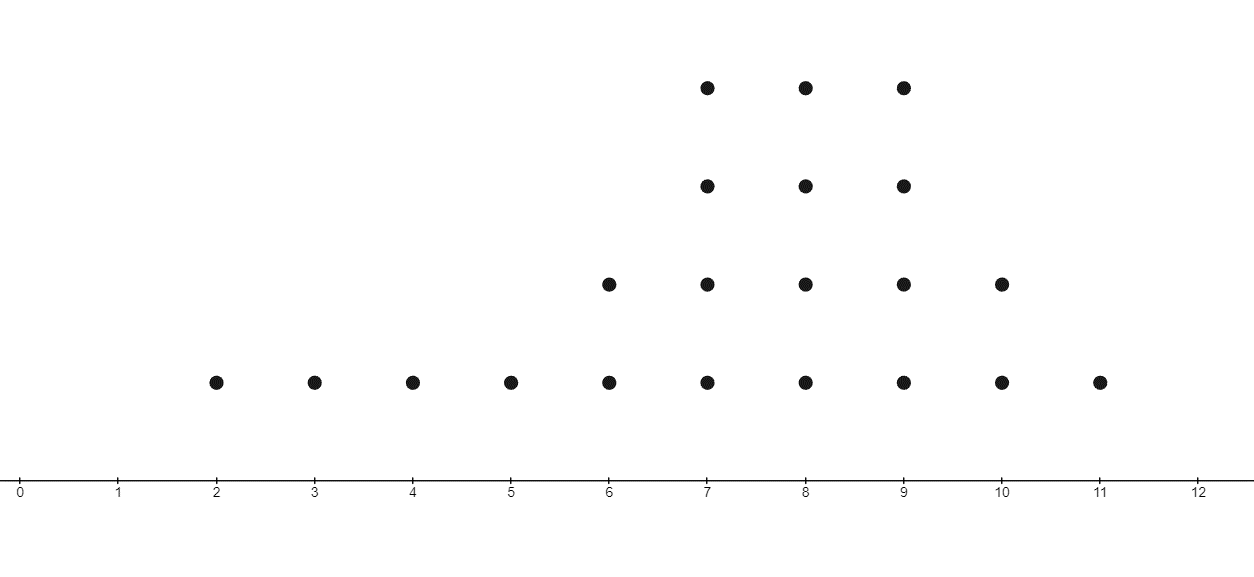
##### Dot plot 2



##### Dot plot 3



##### ****Dot plot 4****



## Appendix B

### More golf data

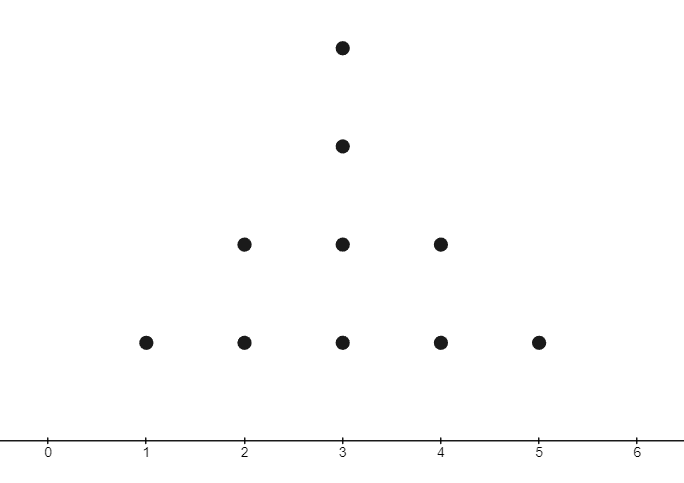
Claim: a golf player would use a driver if they wanted to consistently hit the ball a long distance.4 box plots displaying the range of different golf clubs in metres. The vertical axis from 0 to 250 increasing in increments of 50 m. 
The 5-number summary for the driver 0, 50, 70, 125, 225.
The 5-number summary for the wedge is 0, 25, 50, 75 and the interquartile range is 25.
The 5-number summary for the 6 iron is 0, 50, 70, 125, 200.
The 5-number summary for the hand ball is 130, 140, 150. The box section of the graph is between 130 and 140.

Claim: the Newcastle course requires players to walk the furtherest.

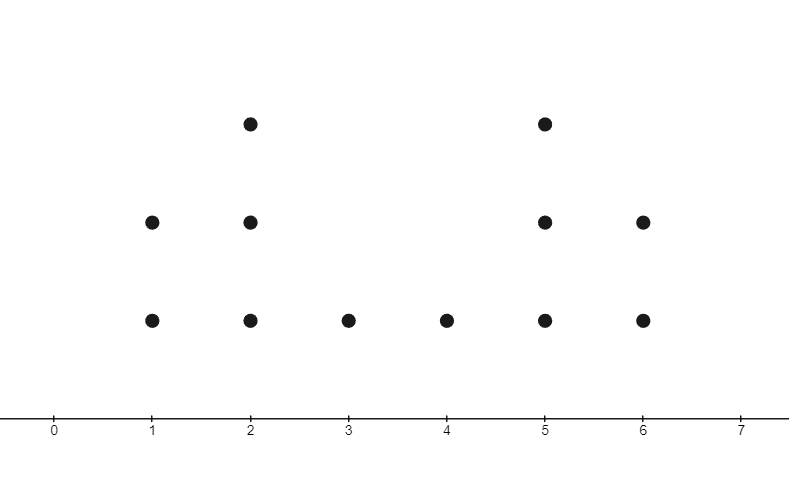
4 box plots displaying the length of the holes at 4 NSW golf courses The vertical axis ranges from 0 to 700 yards increasing in increments of 20 yards. 
The 5-number summary for Newcastle is 158, 300, 441, 495, 623.
The 5-number summary for The Lakes is 140, 262, 362, 444, 525.
The 5-number summary for La Perouse is 150, 263, 375, 420, 505.
The 5-number summary for Ellerston is 160, 340, 440, 481, 580.

## Sample solutions

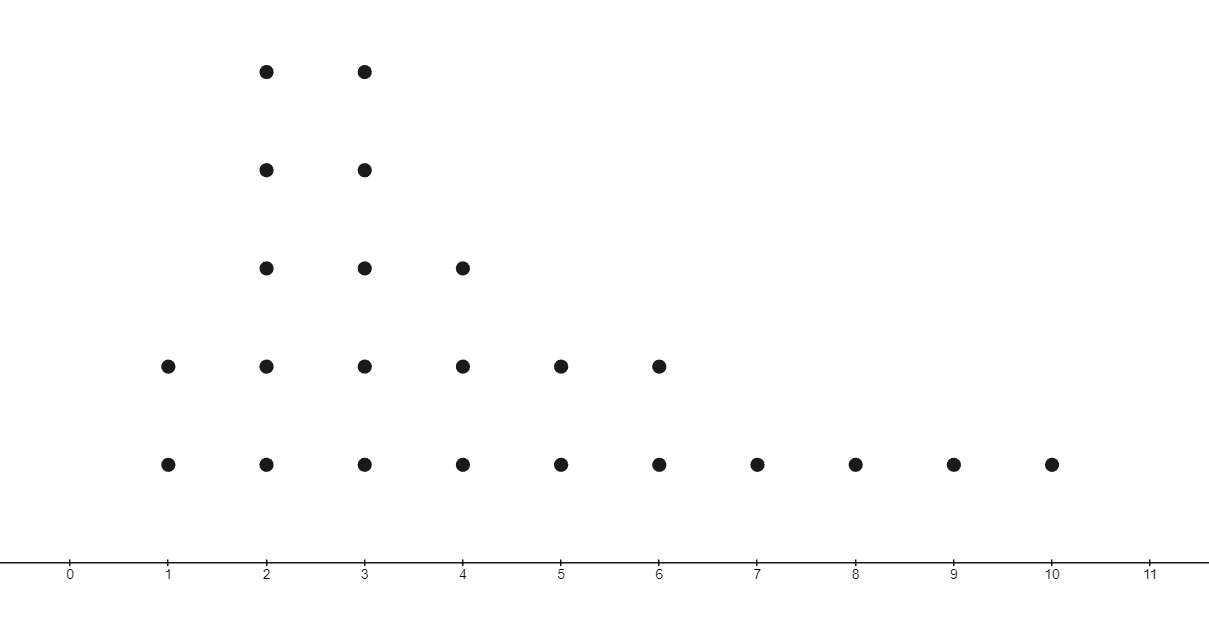
### Appendix A – pass it on



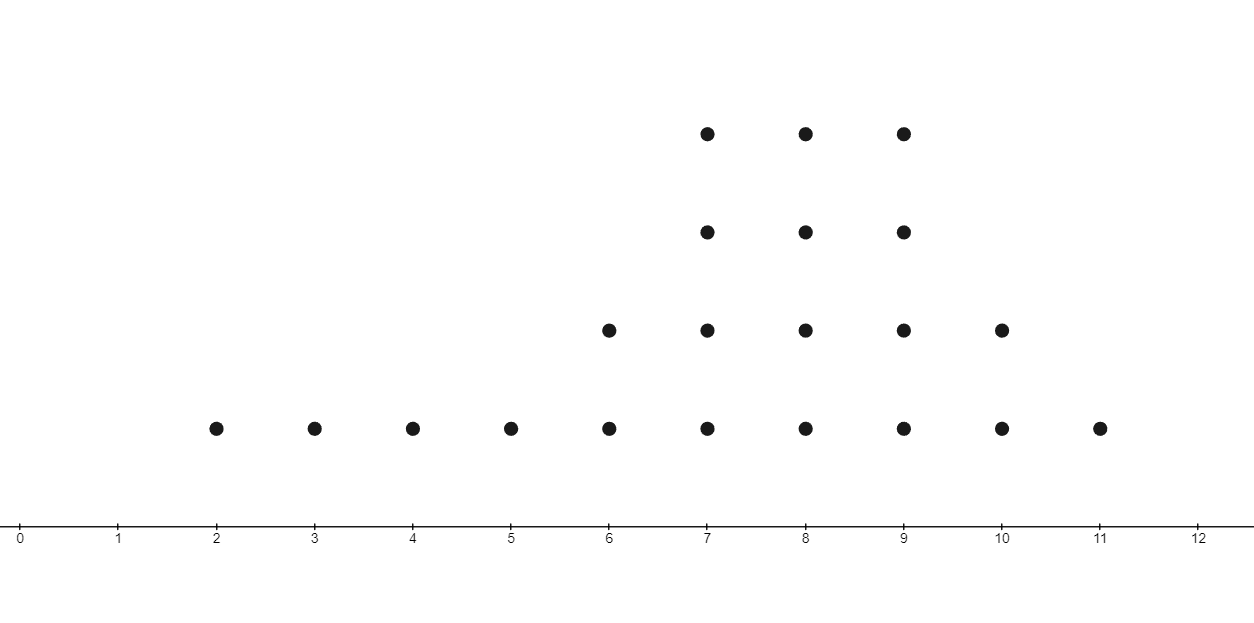
Possible description: the dot plot is symmetrical with numbers going from 1 to 5 on the horizontal axis. The dot plot is unimodal. It has a mode score of 3, which occurs 4 times. Both scores 2 and 4 have a frequency of 2 and scores 1 and 5 have a frequency of one.



Possible description: the dot plot is symmetrical with numbers on the horizontal axis going from 1 to 6 The dot plot is bimodal on scores 2 and 5, which have a frequency of 3. Both scores 1 and 6 have a frequency of 2 and scores 3 and 4 have a frequency of one.



Possible description: the dot plot is positively skewed with numbers on the horizontal axis going from 1 to 10. There are more dots between 1 and 6 than between 7 and 10. The dot plot is bimodal on scores 2 and 3, which have a frequency of 5. The fourth score has a frequency of 3. Scores 1, 5 and 6 have a frequency of 2 and scores 7 to 10 have a frequency of one.



Possible description: the dot plot is negatively skewed with numbers on the horizontal axis going from 1 to 11. There are more dots between 6 and 11 than between 2 and 5. The dot plot is trimodal on scores 7, 8 and 9, which have a frequency of 4. The scores of 6 and 10 have a frequency of 2. Scores 2 to 5 and score 11 all have a frequency of one.

## References

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