Curriculum level: 5+

Teacher's Notes: Are you a masterpiece?

Note: a significant amount of work may require the use of scatterplots and working with bivariate data

This investigation may take anywhere from 2 to 5 lessons. The resource has been created for students and teachers with strong mathematical skills and prior knowledge. Spend some time discussing the context with the students as the more background information a student has the more relevant the investigation may become. You might want the students to work in small groups so they can discuss their work with each other.

The purpose of this activity is to carry out a statistical investigation in the same way a statistician would. The activity may also strengthen students' measurement skills.

Context: You could introduce the activity by talking about Leonardo da Vinci. Here are some interesting facts you may like to use:
Leonardo was so secretive that he never published his ideas and he wrote backwards to disguise them.
Leonardo was the greatest painters of the Italian Renaissance, yet he left only a handful of completed paintings. One of these is the Mona Lisa. She is regarded as the most beautiful woman; possibly because she was painted using his theories of body proportions (she doesn't have any eyebrows though).

To find more information on Leonardo and his investigations into body proportion try using the search words 'vitruvian man'.

Resources checklist

For each group:

- □ Ruler and string or a tape measure
- □ Graph paper or access to computer or calculator

Problem

As an Investigative activity, students should discuss each part of the question so that they understand what they are investigating.
The students should all be clear on what they are going to answer

Plan

This activity has been written to allow for both collecting data from the class and obtaining it from Censusatschool.
A) If obtaining the data from CensusAtSchool. Students will need access to computers and perhaps printing (for large samples).

B) If student wish to investigate data from their class, they will need access to measuring equipment.

Students learn more effectively if they are encouraged to make predictions and then to test them and reflect on the difference between their prediction and the result.

Without a good plan, students may lack focus and direction for the activity. It is considered an important part of the investigation.

1. What factors do you think should be explored when investigating this theory? Height and Arm span are the obvious factors. Gender and age could also be factors. Students should be encouraged to come up with factors they think can assist in solving the problem.

2. What data will you need to collect to carry this investigation out? Data on the factors they considered should be collected. They may think of things such as age, ethnicity, gender and so on.

3. Who will you collect data from? From CensusAtSchool, From the class, a mixture of both?

4. How will you collect the data? CensusAtSchool will take a random sample. If students wish to sample the class, what type of sample will they take? Systematic, cluster, random? Accuracy of measuring to be considered. Method employed.

5. Are you a masterpiece? Make a prediction now, before you gather your data. Students learn more effectively if they are encouraged to make predictions and then to test them and reflect on the difference between their prediction and the result.

6. Who would be interested in your conclusion? Immediate – Teacher, student. Hypothetically – Media, school uniform/clothing manufacturer, School employed architects, businesses involved in manufacturing school desks/chairs…

Data

CensusAtSchool has data on height and arm span measurements. It is also suggested that students add their own data to the set.
How will you record the data when you collect it? You might like to record your data in a table like the one below. Student should be encouraged to decide on what factors they feel are important, Gender, age or ethnicity. Student could add another column, the height to arm span ratio.

Analysis

When students look at the data table they should notice features like largest or smallest measurements, Students should be cleaning the data where and when appropriate.

1. Do you wish to change your prediction? Students should be encouraged to re-evaluate their predictions as information comes to light.

2. Is there any data which looks unusual and if so what may account for this? A noticeably large or small measurement. The most likely reason could be inaccurate measuring.

3. Is there anyone in your sample who is a masterpiece and how can you tell?
The ratio x/y = 1.

4. Why do you think some people have slightly different arm spans compared to their heights? Students will arrive with many different explanations. Two main ideas being 'nobody's perfect' and 'Leonardo's ratio is incorrect.' Other aspects such as ethnicity affect ratio are equally valid. They will find that most of the students' heights are not exactly the same as their arm spans. This is because the students are real and so vary slightly. Students may also have stretched their arms more than others or stood taller rather than slouched (although extreme cases where for example students stood on tippy toes may have already been cleaned or at least flagged). One of the key aims of statistics is to deal with the variation in data and to say whether it is natural or random or whether it is caused by something else.

5. Draw a graph of your data. You might have to draw a few graphs to show all the information. Students should be encouraged to create their own graphs rather than being told which graph to use so that they have ownership of the discovery process. If they only plot one measurement encourage them to think how they might plot another measurement on the same graph. They may calculate the ratio between height and arm span first and then just plot a frequency graph of these. They may create a scatter plot of one measurement against another.

6. Have you graphed one measurement against another measurement? What do you notice about the data? If the students plot one measurement against another to create a scatter plot they will find that all their data form a diagonal clump in the middle of the plot.

7. How could you describe the shape of the plotted data? Allow student to use their own words to describe the shape of the distribution.

8. Draw a line through the middle of it. What is the slope of the line?
The student should have a positive line of best fit with a gradient of about 1.

9. What does this tell you about the data? There is a positive association between arm span and height. As arm span increases by 1cm, height also increases by 1cm.

10. Are there differences between groups of students (male/female, ethnicities, etc)?
A difficult question as students need to explore the ratio's more carefully, look within the data and then decide if the differences are significant.

11. Do you think the results would be the same for other groups of people? Why? Babies may not have the same arm span to height ratio as they are still growing. Other nationalities may have slightly different ratios too. Teenage boys may have slightly different proportions as their bodies rapidly change during puberty.

In your books record your thoughts about your graphs using these sentence starters:
I noticed that…
I wondered if… (What do you wish you had information on? Have another look at Leonardo's drawing. These sentences often help student think about what they have investigated and assist in focusing their thoughts back to the problem.

Have another look at Leonardo's drawing. What other body proportions are the same? What could you investigate next?
There are many body proportions to investigate for example your belly button is half way between the soles of your feet and your arms above your head. The length of your hand is one-ninth of your height. Your kneeing height is three quarters of your standing height.

Conclusion

Student's conclusions should relate back to their original question. They should also mention any features they had noticed or wondered about and investigated. Introduce probabilistic thinking – what is the likelihood of a student in another class being as tall as their arm span is wide?
The use of statistical language should be encouraged to help students construct a conclusion.
If all your body measurements were related to each other then you could draw someone from just one measurement. This is the basics of forensic science – just one foot print will provide all the other body measurements of the thief. Fashion designers could also design clothes for you from just one measurement.