

Measurement errors

Introduction

Some ideas for a quick activity to demonstrate the inherent error in any measurement, using thermometers, watches or rulers. It shows how even a simple measurement is subject to both random and systematic error.

Requirements

A set of thermometers, a large analogue clock or a set of rulers.

Activity - Using thermometers

Pose the question “What is the temperature in the classroom?”.

Ask students to read their thermometers. Display all the results.

Discuss the range of results and the reasons for the differences in the values.

There will be random errors because:

- of the difficulty in reading a thermometer accurately
- the temperature will vary throughout the room.

Individual thermometers are subject to systematic error because the thermometers are not all calibrated to an identical standard. Systematic errors can also be demonstrated if all the thermometers are closer to a radiator or open window.

Calculate the mean and discuss its accuracy with questions such as:

- Do we know the true temperature?
- Can we know the true temperature?
- What would be the effect on the mean of ignoring an outlying value?
- How would you express the mean temperature with an estimate of the uncertainty expressed as $\pm \dots$?

Activity - Using watches

If you don't have thermometers you can do a similar activity using time measurement. Get all the students to record a time interval, signalled by clapping your hands. Start by using the analogue classroom clock and reading it as accurately as they can. There will be a range of answers due to random errors in reading the clock. Display the results.

Then get them to do the same thing using their own watches. Display all the results. Discuss the range of results and the reasons for the differences in the values.

You will get a set of high precision results from those with digital watches but are they all the same? There will still be random errors, mainly due to their own reflex time. Those using analogue watches will get results with less precision and more random error. Systematic errors will not show up over a short time interval. If the activity simply recorded the time at a single moment, rather than an interval, systematic error would be very significant.

References

Specification 12.1

Appreciate that you can never be sure that a measurement gives the 'true' value of the quantity being measured, and be able to give some reasons why

Textbook Page 148-149

Calculate the mean and discuss its accuracy with questions such as:

- Do we know the true time interval?
- Can we know the true time interval?
- What would be the effect on the mean of ignoring an outlying value?
- How would you express the mean time interval with an estimate of the uncertainty expressed as $\pm \dots$?

Activity – Using rulers

Get all the students to measure the length of the same object. The SPU textbook might be suitable if some students have them. Display the results.

Discuss the range of results and the reasons for the differences in the values.

There will be random errors because:

- of the difficulty in reading a ruler accurately
- the books themselves may not be identical.

Individual rulers will be subject to systematic error because the rulers are not all calibrated to an identical standard.

Calculate the mean and discuss its accuracy with questions such as:

- Do we know the true length?
- Can we know the true length?
- What would be the effect on the mean of ignoring an outlying value?
- How would you express the mean length with an estimate of the uncertainty expressed as $\pm \dots$?