Curtin College

Statistics and Origami

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Inspiration

Nearly 20 years I wrote an assignment on teaching aids.

My idea was to have fun, hands-on teaching aids that cost nothing.

I started with rock, scissor, paper...which grew to include Playdough and string.

My specialist resources were:

- a Playdough recipe https://www.mckenziesfoods.com.au/recipe/playdough/
- "Unfolding Mathematics with Unit Origami" by Betsy Franco.

Origami is more than paper cranes

I initially introduced origami to my 1st year engineers to engage them with space , vectors, error and the application of origami beyond paper cranes.

My latest assignment is Origami and Statistics.

My aim is for students to appreciate that:

- Mathematics is not just about numbers and algebra it is about space.
- Mathematics allows us to model reality.
- Reality is messy and full of assumptions and errors.
- Beware poor quality data – garbage in, garbage out.

Squareness

- Most books focus on origami and geometry
- There is an assumption that you buy the origami paper. $$$
- I bought cheap origami paper that was not quite square.
- This was very annoying and the inspiration for an assessment!

"A square is that which is both equilateral and right-angled".

Euclid's Elements. Book 1, Definition 22.

Task

- **Make**
  - Origami paper from magazines or newspaper.
  - You are not to use bought origami paper.
- **Collect**
  - Data to evaluate the “squareness” of your origami paper.
- **Construct**
  - A polyhedral model using unit origami. The model must have at least 17 faces.
- **Analyse**
  - The paper for squareness using the statistical techniques covered in this unit.
  - Provide a conclusion that is supported by the data analysis.
- **Critique**
  - All aspects of: **Make, Collect, Construction** and **Analyse**.

Make Paper – 10 marks

- Choose dimensions that are not commercially available; last time I chose 190mm x 190mm.
- Paper must be recycled – my favorites are made of junk mail.
- There is a lot to be learnt from having to use poor quality construction materials such as newspaper or flimsy menus.
- Making a square is logical doing it well is surprisingly difficult.

Problems

- Use bought paper – 0 marks
- Paper is wrong size – 0 marks

Collect Data -20 marks

- The biggest challenge is deciding what data to collect.
- Evidence needs to be provided that measurements are precise and accurate and that the data is credible.

Problems

- Only collect side length data .
- Have data on sides 1, 2, 3 & 4 and treat them as separate data sets.
- Too many or too few decimal places.
- Do not provide proof that measurements are precise and accurate.
- Data is not credible or fabricated.
- No data.

Construct Model – 20 marks

Polyhedral model with at least 17 faces. Quality construction – sharp edges, minimal gaps, no other materials used.

- Unit origami is the IKEA of origami.
- Polyhedron are structurally sound and beautiful.

Problems

- None!
- Students worry that their model is flimsy as a result of using thin and or slippery glossy paper.
- I am happy that they are considering the impact of material selection.

Analyse Data - 20 marks

Rubric pointers

- Create histogram(s) of primary data.
- Calculate mean and standard deviation(s) of population data.
- Calculate mean and standard deviation(s) for an SRS of size n=10.
- Determine 95% confidence intervals for SRS of n=10 when σ is known.
- State and test appropriate hypotheses for evaluating the squareness of the origami paper at a 5% level of significance when σ is unknown for an SRS of size n=10.
- Provide detailed calculations and state any necessary assumptions.

Analyse Data - 20 marks

What goes well?

- Application of techniques.
- Confidence intervals and hypothesis are easy to mark.
- Students find creative ways of achieving SRS.

Problems

- Lose sight of what the task is – evaluate squareness.
- Only evaluate side lengths or area.
- Evaluate 4 sides separately.
- Forget angles.
- Poor quality graphics - weird intervals on histograms.
- Lack of assumptions and supporting calculations.

Critique - 20 marks

To critically reflect on all aspects of the assignment.

- The method of the manufacture of origami paper and model.
  - What went well and what would they do differently?
- Data collection.
  - Was the data collected appropriate to assess SQUARENESS?
  - Did they consider other data?
- Determination of SRS.
  - Very funny. Some used random number generators but there were blindfolded team members having to point at a screen and pulling numbers out of a hat.
- Appropriateness of the statistical methods used against the data set(s).
  - Was the data symmetrical enough to assume a normally distributed population?

Current Marking Rubric

Marking Rubric
Make Paper - 10 marks • Student manufactured square origami paper using magazines, newspapers or other recycled paper. • Dimensions 190 mm x 190 mm.
Collect Data - 20 marks • Data collected is appropriate for the assessment of the squareness of the origami paper. • Precision of measurements is validated. • Proof that data is credible.
Construct Model - 20 marks • Polyhedral model constructed using unit origami with at least 17 faces. • Quality construction – sharp edges, minimal gaps, no other materials used.
Analyse Data - 20 marks • Create histogram(s) (using appropriate intervals) and box plot(s) of primary data. • Calculate mean and standard deviation(s) of population data. • Calculate mean and standard deviation(s) for an SRS of size n=10. • Determine 95% confidence intervals for an SRS of size n=10 when σ is known. • State and test appropriate hypotheses for evaluating the squareness of the origami paper at a 5% level of significance when σ is unknown for an SRS of size n=10. • Provide detailed calculations and state any necessary assumptions.
Critique - 20 marks • The method of the manufacture of origami paper and model. • Data collection. • Determination of SRS. • Appropriateness of the statistical methods used against the data set(s).
Report - 10 marks • Cover page includes: informative title, unit name. author names & ID's and image of model. • Spelling and grammar correct. • Logical report structure including decimal notation and informative section headings • All images are: titled, labelled, carefully chosen to explain statistical concepts and referred to in-text.

Resources

The internet has transformed origami.

- **Basic search terms:** Unit origami, modular origami, folding pleating, folding techniques, v pleat, other pleats, spans and parabolas…

Brigham Young University (2017). *Bullet-proof origami: Folding Kevlar shield designed by BYU mechanical engineers.* Retrieved July 22, 2109 from https://www.youtube.com/watch?v=P_ezsOeX5mQ

Franco, B. (1999). *Unfolding mathematics with unit origami*. Key Curriculum Press

Jackson, P., (2017) *Folding Techniques*, retrieved July 22, 2019, 2017 from http://foldingtechniques.com/folding-techniques

Jackson, P., (2019) *Origami Artist*, retrieved July 22, 2019 from http://www.origami-artist.com/

Metzger, J., (2017). *The Origami revolution* Retrieved July 22, 2019 from https://www.youtube.com/watch?v=YDBWLKwIAgE

Nakashima, J., (2019), Origami Fireworks, retrieved 25 July 2019 from https://www.youtube.com/watch?v=z0-mlZvJD-E

Origami Instructions. (2005). *Modular Origami folding instructions - how to make a modular Origami.* Retrieved July 22, 2019, from Origami-instructions.com, http://www.origami-instructions.com/modular-origami-instructions.html

Origami Resource Center. *Modular: Free diagrams instructing you how to fold unit origami models.* Retrieved July 22, 2019, from Origami Resource Center, http://www.origami-resource-center.com/modular.html

Tomoko Fuse. (1990). *Unit origami: Multidimensional transformations*. Japan Publications.

What I tell my students...

Prototype

Formulas are models of reality but they are not reality

Reality is messy

Minecraft is not reality

You do have to know something

You do not know everything – ask questions

Test your assumptions and calculations. Do they make sense?

What was the task?

Where is the evidence?