Texas A&M RET

Applied Statistics Curriculum

Brad Whitehead

Summer 2022

Acknowledgements

Principal · Elizabeth Raska
Clear Lake High School
2929 Bay Area Blvd
Houston, TX 77058

This program is made possible by:

- Department of Engineering Technology & Industrial Distribution at Texas A&M University
- National Science Foundation
- Gene Haas Foundation

Acknowledgements

Principal · Elizabeth Raska
Clear Lake High School
2929 Bay Area Blvd
Houston, TX 77058

This program is made possible by:

- Department of Engineering Technology & Industrial Distribution at Texas A&M University
- National Science Foundation
- Gene Haas Foundation

Issue and Motivation

The current Statistics 1 course when taught in a traditional lecture style can be:

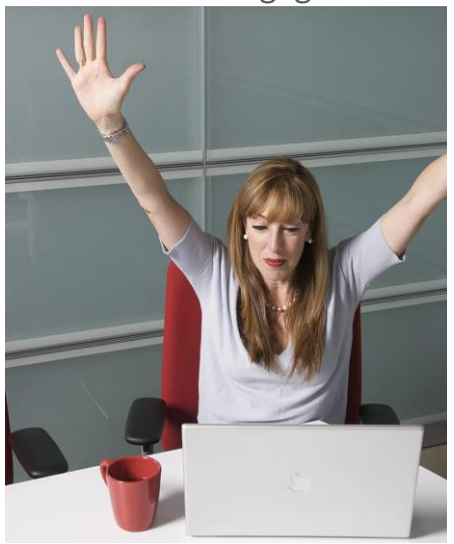
- Abstract
- Tedious
- Dull

https://www.freepik.com/free-photo/girl-focus-class_9098808.htm

Goal - Teach statistics through hands-on projects including metrology and 3 dimensional (3D) printing

Outcomes:

- Students take ownership over learning
- Develop intellectual curiosity
- Increase student engagement



https://www.pikist.com/free-photo-xepbc

3D Printing Curriculum Plan

Target Grade/Subject: 11-12th Grade/ Statistics
Unit: Probability and random variables (TEKs 111.47.5)
Lesson Title: Exploring randomness of dice rolls
Length: 3 weeks

https://www.printables.com/model/115641-magic-dice-marked-dice-loaded-dice-gezinkter-wurfe

https://www.prusa3d.com/product/original-prusa-mini-kit-2/

3D Printing Curriculum Plan

Summary of Lesson:

- Students will use a Computer Aided Design (CAD) software called Onshape to design a standard 6 sided dice. Onshape is free for education, works in the browser, and works on most devices. It is easy to use and students can learn the basics in a few days.
- They will begin manufacturing their design starting with their 3D model. Using a free slicing software called PrusaSlicer, students will convert the 3D model into instructions for the printer. Working with a partner they will test the probability of single and double dice rolls for each number and record the data in a spreadsheet.
- Then they will design and manufacture unfair dice. The 3D printer will allow the dice to be manufactured with varying density. They will test the probability again and record the data in the same spreadsheet.
- They will be able to compare the two datasets to confirm if the dice are unfair and summarize their findings in a report.

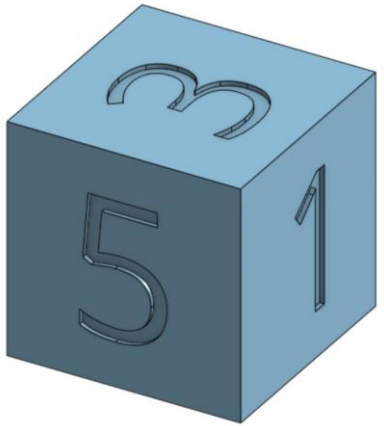
3D Printing Curriculum Plan

Learning Objectives:

Students will:

- understand relationship between theoretical and empirical probabilities using the Law of Large Numbers
- calculate probability
- construct a distribution plot using a spreadsheet
- use CAD to design 3D models
- understand basic 3D printing principles

Example die CAD model



3D Printing Curriculum Plan

Instructional Activities:

Time	Activity	Resources
3 days	Onshape sign up and basic overview	Computers, Onshape
2 days	3D printing overview and Prusa slicer software training	3D printers, computers, Prusa Slicer
1 week	Design, print, and test fair dice	3D printers, computers, Excel, Prusa Slicer, Onshape
1 week	Design, print, and test unfair dice	3D printers, computers, Excel, Prusa Slicer, Onshape
1 day	Class discussion of project and analysis of data and final report	Computers
Extension	Non-Transitive dice (dice with paper-rock-scissors-lizard-spock properties)	

3D Printing Curriculum Plan

Deliverables:

- 3D models of fair and unfair dice
- 3D prints of fair and unfair dice
- Spreadsheet data including:
  - Raw data from fair dice rolls
  - Distribution plot of data of 1 dice roll and 2 dice rolls
  - Raw data from unfair dice rolls
  - Distribution plot of data of 1 dice roll and 2 dice rolls
- Final report including summary and analysis of data

https://www.publicdomainpictures.net/en/view-image.php?image=370816&picture=two-dice-fly-on-the-roll

Metrology Curriculum Plan

Target Grade/Subject: 11-12th Grade/ Statistics
Unit: Statistical process sampling and experimentation (TEKs 111.47.2)
Lesson Title: Understanding tolerance, variance, and precision in mass produced products
Length: 2 weeks

https://www.flickr.com/photos/30478819@N08/30591551427

Fowler Digital Calipers

https://m.media-amazon.com/images/I/51uJ216FTpL._SL1200_.jpg

Dino-lite microscope

https://m.media-amazon.com/images/I/61YvGOfRTVL._SL1500_.jpg

https://commons.wikimedia.org/wiki/File:Light_Green_Lego_Brick.jpg

Metrology Curriculum Plan

Summary of Lesson:

- Students will use contact (Fowler digital calipers) and non-contact (Dino-lite microscope) metrology to measure Jenga blocks length, width, and height.
- Students will record the data in a spreadsheet, calculate the volume of each block, and construct a distribution of individual block volume.
- Students will then measure the length, width, and connector diameter of the “generic Lego” and “official Lego”. They will record the data, and construct a distribution for each measurement.
- Then, they compare the variance of generic vs official and summarize their findings in a report.

Metrology Curriculum Plan

Learning Objectives:

Students will:

- be able to use digital calipers
- be able to use microscope metrology
- compare and contrast the benefits of different sampling techniques
- communicate methods used, analyses conducted, and conclusions drawn for a data-analysis project through a written report

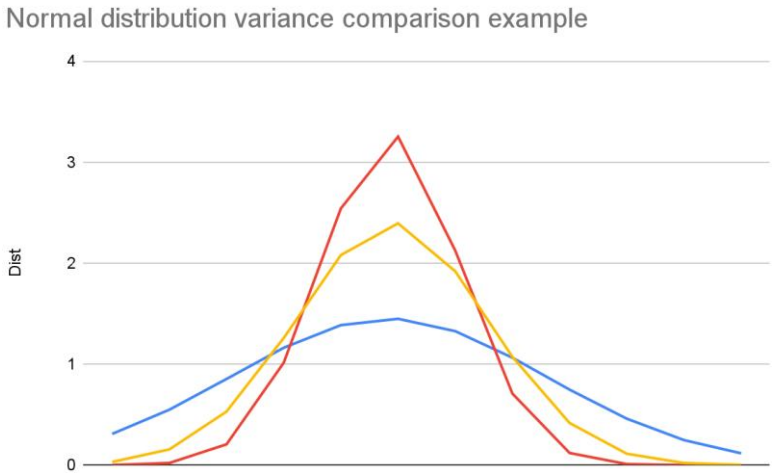
https://www.instructables.com/Designing-Fully-Parametric-LEGO-compatible-Pieces-/

Metrology Curriculum Plan

Learning Objectives:

Students will discover that Jenga blocks are different sizes in order for the game to be played effectively. They will measure length, width, and height and calculate volume to avoid confusion about conventions.

Generic Lego is manufactured and intended to be identical sizes. They usually have a larger variance than the official Lego which can have a tolerance as low as 10 micrometers[1].



1- https://en.wikipedia.org/wiki/Lego#:~:text=Each%20Lego%20piece%20must%20be%20manufactured%20to%20an%20exacting%20degree%20of%20precision.%20When%20two%20pieces%20are%20engaged%20they%20must%20fit%20firmly%2C%20yet%20be%20easily%20disassembled.%20The%20machines%20that%20manufacture%20Lego%20bricks%20have%20tolerances%20as%20small%20as%2010%20micrometres.

Metrology Curriculum Plan

Instructional Activities:

Time	Activity	Resources
1 day	Digital caliper training and practice	Digital calipers
1 day	Digital microscope/metrology software training and practice	Digital microscope, metrology software, computers
2 days	Break into groups and measure Jenga blocks. Half the students will use calipers to measure and the other half will use the microscope software. Record data in spreadsheet.	Digital microscope, Digital calipers, metrology software, computers, Jenga blocks
3 days	Break into groups and measure Lego. Half the students will use calipers to measure and the other half will use the microscope software. Record data in spreadsheet.	Digital microscope, Digital calipers, metrology software, computers, generic and official lego
1 week	Generate distributions from datasets. Analyze and summarize in final report.	Computers

Metrology Curriculum Plan

Deliverables:

- Spreadsheet data including:
  - Length, width, height data from Jenga blocks
  - Jenga block volume calculations
  - Distribution plot of Jenga data
  - Raw data from official and generic Lego
  - Distributions from each Lego dataset
- Final report including summary and analysis of data

Official (left) vs Generic Lego (right)

http://www.brickfinder.net/2020/08/30/fake-lego-imprinted-bricks-found-china/

Equipment & budget

Qty	Item	Price ($)	Total ($)	Source
2	Prusa Mini 3d printers	459.00	918.00	https://www.prusa3d.com/product/original-prusa-mini-kit-2/
3	Digital microscopes	99.00	297.00	Amazon B00GA9QJQY
3	Microscope stands	39.00	117.00	Amazon B074TLHR8P
5	Digital calipers	48.36	241.80	Amazon B0015S6GMM
1	'Jenga' blocks	15.79	15.79	Amazon B01M3SRTCE
1	Generic lego set	27.99	27.99	Amazon B07YN22FRW
1	Official lego set	13.54	13.54	Amazon B015RSIDQC
1	Calibration gauge block set	116.00	116.00	Amazon B00HNU3JDU
		Total	**$1,747.12**	

Filament for the 3D printers and batteries for the calipers will be purchased with the classroom budget. The teacher will perform maintenance on the 3d printers. The printers are open source and will be able to print some of their own replacement parts and upgrades.

Assessment and impact:

Formative assessments will be given at the beginning of the 3D printing and Metrology projects. Summative assessments will be given at the end of each project to get an idea of effectiveness of the curriculum and to gauge student growth. The goal is to increase student average 1 full letter grade from the formative to the summative.

Students will take a qualitative self assessment to gauge growth in critical thinking, with a 10% expected increase. Summative data will be available next summer.

These projects are expected to increase interest in the engineering program from students not currently taking engineering courses. Engineering enrollment is expected to increase enough to add an additional section next year. Field trips to University of Houston Clear Lake or A&M University respective engineering departments would provide enrichment. Student enrollment can be tracked to look for positive correlation.

Data from last year is not available.

University of Houston Clear Lake

https://upload.wikimedia.org/wikipedia/commons/5/5e/UHCL_logo_%282%29.png

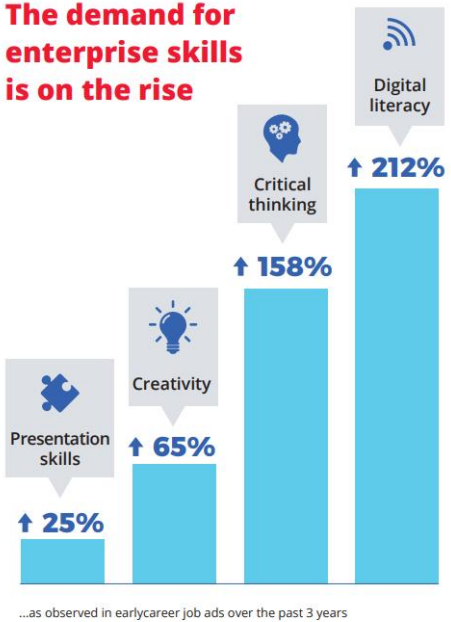
Summary

These new lessons will be taught in an existing Statistics course for the upcoming 22/23 school year corresponding to the appropriate course topics. There will be enough time to purchase supplies.

In accordance to my district's desired course outcomes:
"Students will connect data and statistical processes to real world situations. In addition, students will extend their knowledge of data analysis. "

The 3D printing dice and Metrology lessons will allow students to connect statistics to real world situations. They will also develop critical thinking through project based learning, which is in high demand.

The students will be able to experience hands-on projects and to have unique experiences that are not possible in a traditional classroom environment.



https://www.fya.org.au/app/uploads/2021/09/The-New-Basics_2016.pdf