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Tactile Aids for Teaching Statistics to the Visually Impaired

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Abstract

This case study explored the use of haptic tools to teach concepts in introductory statistics to a blind student. Statistics education typically relies heavily on the visual modality, which limits accessibility for the visually impaired. Our study made use of tactile aids such as LEGO building blocks, push pin diagrams, and 3D printed models to demonstrate typical statistical concepts such as histograms, normal distributions, skewed distributions, central tendency, and scatterplots. We argue that such models are beneficial for elucidating course material which is typically taught visually. For example, 3D printed models were able to highlight all the same components of the standard normal distribution as visual drawings do, making a complex topic easily understandable. The aim of this project is to establish an easily-accessible, replicable model for utilizing these tools and methods to teach statistical concepts. This work has implications for teaching statistical content to those with visual impairment, and may also serve as a valuable supplement for any student of statistics.

TACTILE AIDS FOR TEACHING STATISTICS TO THE VISUALLY IMPAIRED

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INTRODUCTION

This project explored the development and use of haptic tools to teach concepts in introductory statistics to visually impaired and blind students. We demonstrate that content which is traditionally taught visually can be made accessible and understandable using tactile teaching aids that are affordable and easy to create.

The aim of this project is to establish an easily-accessible, replicable model for utilizing these tools and methods to teach statistical concepts utilizing non-visual modalities.

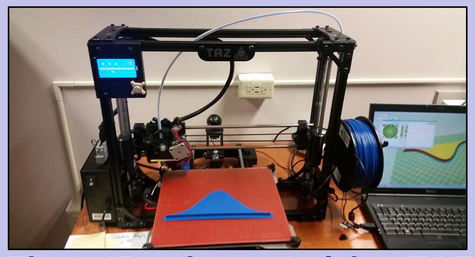


Fig 1. 3D print on Lulzbot TAZ

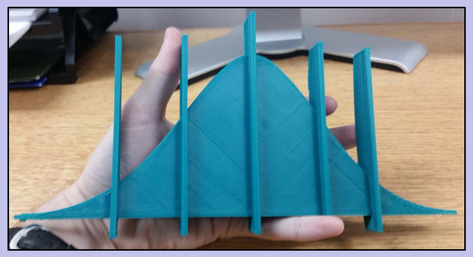


Fig 2. The Empirical Rule

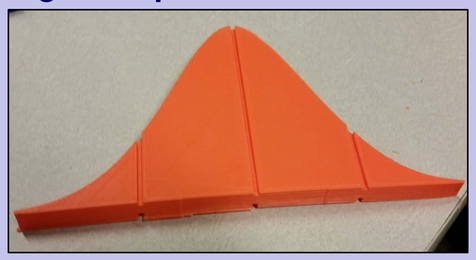


Fig 3. Proportions of the curve

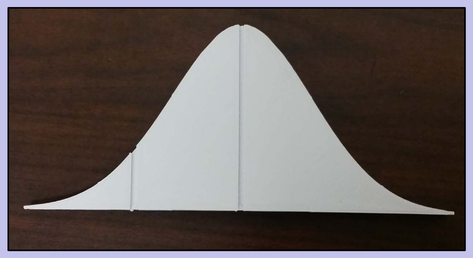
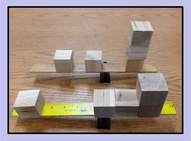


Fig 4. One-tailed tests

OPEN EDUCATION RESOURCES

3D printing has become increasingly accessible and affordable for instructors and students across the globe, thanks to the proliferation of Maker Spaces. Maker Spaces - often housed in libraries - play a vital role in leveraging new technologies like 3D printing for accessibility.

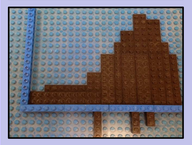
There are very few existing 3D printing designs related to introductory statistical content. Our designs are shared on an open access platform under a Creative Commons license to allow others to use this work, as well as to build on and improve it.



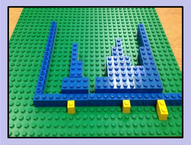
LOW TECH SOLUTIONS

<u>Central Tendency (Rulers)</u>
Mean, median, mode, and mean as literal balance point.

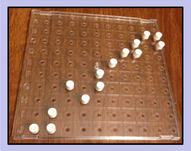
<u>Continuous Histogram (Pushpin)</u>
Normal, skewed, bimodal and other shapes, and notches show effects of skew and outliers on central tendency.



<u>Discrete Histograms (LEGO)</u>
Distribution shape, spread, and center. Bumps allow easy counting to calculate. Notches show mean, median, mode(s).



<u>Scatterplots (Battleship)</u>
Positive/negative correlation, weak/strong, outliers.



<u>Tabled z, t, F, X^2 Values (Excel)</u>
Tabled values in textbooks are inaccessible. We programmed Excel to work with a screen reader to report tabled values.

3D PRINTED SOLUTIONS

Standard statistics courses invariably use visual diagrams to help students understand the normal curve, calculate proportions of that curve, and identify critical values along the curve for hypothesis testing.

We designed and 3D printed (Fig. 1) a set of hands-on tactile models of the normal curve by adapting and improving a preexisting prototype model on the design sharing site Thingiverse.

Our initial designs used raised bars to mark standard deviations (e.g., to demonstrate Empirical Rule of 68-95-99.7%, Fig. 2), but with feedback we found that cutting channels into the model was more effective.

We created designs with two channels on the right or left side, one on each side of the mean (Fig. 3), or a single channel on one side (Fig. 4), providing a tactile reference to use for calculating proportions of the normal curve (including one-tailed and two-tailed hypothesis testing).

The models are easy to print, easy to adapt or iterate, and the end product is mobile, lightweight, and robust for a student to carry in a backpack and use during class.

CONCLUSIONS

Tactile aids can highlight the same concepts and components as visual drawings, making complex topics easily understandable regardless of visual ability.

3D printing, by utilizing a collaborative design approach, facilitates the creation and iterative improvement of learning tools that can address individual needs. 3D printing has become generally accessible thanks to open-access online platforms and the growing number of Maker Spaces.

Making a classroom accessible requires considerable forethought. Rather than expecting creators to reinvent the wheel, we advocate for designing open access tools that can be easily shared, improved, and adopted by teachers and learners anywhere. An efficient and flexible process for developing and sharing learning materials makes it easier for tools created for one student/situation to be generalized or adapted to other students/situations.