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Introduction

A. Introductory statistics courses typically consist of elementary methods and textbook examples of their application. (Carver, College, and Everson 2016) (Tintle et al. 2021)

B. One shortfall of such courses, albeit not unheard of, is that students seldom have the opportunity to participate in a statistical experiment. (McGowan 2011) (Ashaari et al. 2011)

C. Graphical displays of data are an important aspect of statistics and have well-established guidelines. (Cleveland and McGill 1984) (Heer and Bostock 2010) (Loy 2021)

D. However, the current state of 3D visualizations is mainly limited to their 2D projections, providing an opportunity for experiential learning in a novel area of true 3D graphics. (Kraus et al. 2020) (Fisher, Dempsey, and Marousky 1997) (Barfield and Robless 1989)

E. In this paper, we discuss the use of a graphical study in an introductory statistics classroom environment and its application as an educational tool.

Methods

Designing a Graphics Experiment

A. We draw inspiration from Cleveland and McGill's seminal work on graphical perception to design our graphics study. (Cleveland and McGill 1984)

B. Our modernization of the 1984 study led us to create a Shiny app to collect data and administer the digital graphs. (Chang et al. 2023)

- Figure 1: Screenshot from the Shiny app used to administer the experiment.

C. Due to limitations in modern software packages, multiple sources were required to create each graph type. (Microsoft Corporation 2018) (Murdoch and Adler 2023) (Wickham 2016)

D. With 42 treatment combinations, we opted to use an incomplete block design to select five of the seven possible ratios and use each plot type for each ratio.

   - Figure 2: Visual display of the experimental design for students who participated in the 3D bar charts experiment.

E. When administering the experiment, participants are asked to randomly select a bag containing the 3D printed graphs.

Experiential Learning

A. Our experiment and classroom integration were split into six stages: informed consent, pre-experiment reflection, experiment participation, post-experiment reflection, abstract reflection, and presentation reflection.

   - Table 1: List of questions for each module that students completed.

B. Instructors for STAT 218, the introductory statistics course at University of Nebraska-Lincoln, were recruited for Summer 2023, Fall 2023, and Spring 2024 to administer the graphics project into their classroom.

Results

Student Participation

A. Given the nature of the recruitment method, we were only able to recruit a few instructors for Summer and Fall semesters in 2023.

   - Table 2: Number of valid student participants by semester.

Selected Responses from Reflections

A. Prior to the experiment, students generally understood the purpose scientific research.

   - Figure 3: Word cloud for student responses to the pre-experiment prompt.

B. Some students correctly identified parts of the questions asked in the post-experiment reflection, but many missed key components.

C. The abstract unveiled the scope of the study to students, many of whom did not realize the underlying complexities.

D. Lastly, students tended to favor the presentation over the abstract.

Discussion

A. Our results show that students generally appreciated the progressively revealing nature of the graphics project.

B. We acknowledge that our study is not without its limitations.

C. In future studies, we plan to use a similar framework to conduct experiments on more typical 3-dimensional data, such as heatmaps.

References

Link to journal citation style: here

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