

Winter 10-27-2020

**EXPERIENTIAL STATISTICS - A CASE STUDY IN FAVOR OF USING
PROJECT-BASED LEARNING TO ADVANCE PRELIMINARY
STATISTICS CONTENT KNOWLEDGE IN THE ALGEBRA I AND
GEOMETRY CLASSROOM**

Trey Earle

Follow this and additional works at: https://digitalcommons.lsu.edu/education_pubs



Part of the [Educational Assessment, Evaluation, and Research Commons](#)

**EXPERIENTIAL STATISTICS - A CASE STUDY IN FAVOR OF USING
PROJECT-BASED LEARNING TO ADVANCE PRELIMINARY
STATISTICS CONTENT KNOWLEDGE IN THE ALGEBRA I AND
GEOMETRY CLASSROOM**

A Dissertation

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

in

The Department of Educational Leadership, Research & Counseling

by
Trey Michael Earle
B.A., Northwestern (LA) State University, 1999
B.S., Louisiana State University, 2013
MAppStat, Louisiana State University, 2016
December 2020

ACKNOWLEDGEMENTS

I would like to take this opportunity to thank my family, namely my fiancée, Brandi, my son, Austin, and my parents, Steve Earle and Pamela Culp, each for their unwavering encouragement and support during my “late in life” foray (again) into higher education. My cup truly runneth over with each one of them.

I would also like to thank Professor Eugene Kennedy for taking me on as his student. Your knowledge of statistics is amazing, especially as it relates to education. I find myself more and more wanting to follow in your exact footsteps at whatever university will have me.

I want to thank Professor Angela Webb for introducing me to the power of project-based, inquiry-based, and problem-based learning, and Professor Susan K. MacGregor, for showing me the power of mixed methods research. Dr. Webb showed me the relevance and worthiness of each type and how each can yield great results. Dr. MacGregor taught me the power and rich information that can be taken from deep, qualitative data analysis. Both professors have made this purely “quantitative guy” much more well-rounded in research.

I would also like to thank Professor Kevin McCarter for his support over the last three years. He encouraged the Experimental Statistics Department at LSU to consider me to teach my own course in Advanced Statistical Methods, which gave me the opportunity to lead a more advanced statistics course. I thank him for his expertise and support.

Finally, I want to thank Professor Frank Neubrander, whom I met in the summer of 2004 in my early days as a beginning teacher. After asking me to be a part of the GK-12 project at LSU and sending me to become AP Calculus “certified,” I instantly became indebted to him. I consider him to be a very important part of my life, a man who has shaped me into the educator I am today.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS.....	ii
LIST OF TABLES.....	vi
LIST OF FIGURES.....	vii
ABSTRACT.....	ix
INTRODUCTION.....	1
REVIEW OF THE LITERATURE.....	6
Interest and General Attitudes Towards Statistics.....	6
Theoretical Frameworks.....	8
Statistical Literacy.....	11
Professional Development.....	14
National Standards and Benchmarks.....	15
Statistics Education Across the Curriculum and Across Educational Levels.....	16
Project-Based Learning (General and in Statistics Education).....	19
Collaboration Setup.....	27
Technology Use for Statistical Analysis in the Mathematics Classroom.....	28
Gaps in the Literature and Research Questions.....	34
METHODS.....	37
General Structure of the Study and Random Assignment.....	39
Topics of Study by Course.....	42
Protocol for Randomization of Student Groups for Project-Based Assessments.....	45
Experimental Design Used for Student Achievement Portion.....	47

Final Statement Regarding Testing Controls.....	50
Final Study Hypotheses for Achievement Portion.....	52
Statistical Analyses Used for the Student Achievement Portion.....	52
General Structure for Attitudinal Portion of the Research Study.....	53
Statistical Analyses Used for the Student Attitudinal Portion.....	57
Teacher Interview Protocol.....	60
 RESULTS AND DISCUSSION.....	 61
Achievement Portion Results and Discussion for Algebra I Course.....	61
Achievement Portion Results for Geometry Course.....	65
Attitudinal Portion Results.....	68
Participant Frequencies by Demographic/Class Variable.....	69
Internal Consistency and Reliability Analysis.....	72
Paired t Test Analysis on Mean Item Response Change for Each Facet.....	74
Paired t Test Analysis on Changes in Item Responses Within Facet.....	75
MANOVA on Mean Item Differences for Facets by Demographic/Class Variable.....	77
MANOVA on Item Differences Within the Facets by Demographic/Class Variable.....	82
Wilcoxon Signed-Rank Analysis.....	84
Teacher Interview Results.....	95
 SUMMARY AND CONCLUSIONS.....	 100
 STUDY LIMITATIONS AND FUTURE IMPLICATIONS.....	 104
 APPENDICES.....	 105
Appendix A.1: University IRB Approval Documentation.....	105
Appendix A.2: District Research Study Approval Documentation.....	106
Appendix A.3: Local School Principal Approval Documentation.....	107
Appendix B: Prospectus for Approval of Student Projects.....	110

Appendix C: Sample Completed Group Project Prospectus.....	111
Appendix D: Grading Rubric for Student Projects.....	112
Appendix E: Sample Algebra I Group Project Presentation (Names Omitted).....	113
Appendix F: Sample Geometry Group Project Presentation (Names Omitted).....	114
Appendix G: Pre-Unit Survey for Student Attitudinal Portion.....	116
Appendix H: Post-Unit Survey for Student Attitudinal Portion.....	120
Appendix J: Facets of Attitudinal Portion with Statements.....	125
Appendix K: Summary of Variables Used in Attitudinal Portion.....	127
Appendix L: SAS® 9.4 Code for Achievement Portion.....	128
Appendix M: Teacher Interview Questions.....	130
REFERENCES.....	134
VITA.....	142

LIST OF TABLES

Table 1: Topics used in the Algebra I and Geometry Course Statistics Unit.....	43
Table 2: Project Requirements for Project-Based Assessments.....	45
Table 3: Student Randomized Numbers for Project-Based Assessment Groups.....	46
Table 4: Hypotheses for the Achievement Analyses of the Research Study.....	52
Table 5: Table of Frequencies for the Class Variable – GPA.....	70
Table 6: Table of Frequencies for the Class Variable – Math Course.....	70
Table 7: Table of Frequencies for the Class Variable – Expected Math Grade.....	71
Table 8: Table of Frequencies for the Demographic – School Classification.....	71
Table 9: Table of Frequencies for the Demographic – Race/Ethnicity.....	71
Table 10: Table of Frequencies for the Demographic – Gender.....	72
Table 11: Table of Frequencies for the Class Variable – Treatment Method.....	72
Table 12: Cronbach’s Alpha Internal Consistency/Reliability Analysis Results.....	74

LIST OF FIGURES

Figure 1: Descriptive Statistics for Algebra I Student Achievement Portion.....	62
Figure 2: Algebra I Student Achievement Output.....	62
Figure 3: Distribution, Boxplots and Normal Quantile Plots for Algebra I Exam Score Differences by Treatment.....	64
Figure 4: Descriptive Statistics for Geometry Student Achievement Portion.....	65
Figure 5: Geometry Student Achievement Output.....	67
Figure 6: Distribution, Boxplots and Normal Quantile Plots for Geometry Exam Score Differences by Treatment.....	68
Figure 7: Paired t Testing on Means of Item Differences in Survey Results by Facet.....	75
Figure 8: Paired t Test Results for Work Ethic Facet on Changes in Response.....	76
Figure 9: Paired t Test Results for General Attitude Facet on Changes in Response.....	76
Figure 10: Paired t Test Results for General Opinion Facet on Changes in Response.....	76
Figure 11: Q-Q Plots for Multivariate Normality Distribution Assumption in MANOVA.....	78
Figure 12: MANOVA Results on Mean Changes in Response per Item Within Facets.....	80
Figure 13: Mean Significant Difference in Response Change for Method by Facet.....	81
Figure 14: MANOVA on Differences in Response for Each Item within the Work Ethic Facet...	82
Figure 15: Between-Subject Item Effects for Differences in Responses Among Items in Work Ethic.....	83
Figure 16: Symmetry Assumption Check of Work Ethic for Wilcoxon Signed Rank Test	86
Figure 17: Significant Items in Work Ethic from Wilcoxon Signed Rank Analysis.....	87
Figure 18: Symmetry Assumption Check of General Attitude for Wilcoxon Signed Rank Test...	89
Figure 19: Significant Items in General Attitude from Wilcoxon Signed Rank Analysis.....	90

LIST OF FIGURES (CONTINUED)

Figure 20: Symmetry Assumption Check of General Opinion for Wilcoxon Signed Rank Test...	92
Figure 21: Significant Items in General Opinion from Wilcoxon Signed Rank Analysis.....	93

ABSTRACT

Preparing secondary students for college entrance requirements and the expectations of the job market, a market which is actively seeking the employees who are most qualified to take on jobs that require data analysis skills, is becoming increasingly important. Federal, state, and local education administrators and personnel must rewrite many of the general education curricula to incorporate data organization, collection, manipulation, application, and analysis in order to better prepare students for the expectations of college entrance and an ever-changing employment market. From a purely pedagogical standpoint, while traditional educational structure has been commonplace for decades in the United States, projects used as assessment tools are a more progressive way to gauge content understanding and course achievement, especially in mathematics. Algebra I and Geometry students at a lone high school were randomly assigned to participating teachers' classes that were assigned to one of two main treatment groups, one that used projects, the other traditional instruments, as formative assessments, in order to gauge two main goals - the growth in achievement before and after a curricular unit involving statistics and the change in attitudes towards statistics before and after the statistics unit. Using several parametric (paired t testing and MANOVA) and an additional non-parametric statistical analyses on a variety of demographic and class variables and coupled with an interview of participating teachers, the results revealed that projects, from the perspective of both participating students and teachers, often are much more effective in increasing achievement and attitudes towards the science of statistics, especially in the secondary educational years. The results of this study would be useful in rewriting mathematics curriculum to incorporate more focused attention to the science of statistics.

KEYWORDS: project-based learning, statistics education, secondary school mathematics

INTRODUCTION

For some time now, the job market in the United States and around the world has been changing. Decades ago, secondary school graduates who sought employment required only a certain set of job skills, many of a clerical nature, in addition to a basic knowledge of reading, writing and arithmetic. In those days, if a secondary school student had additional trade and vocational skills and he or she had no imminent plans to attend a post-secondary institution, the student would be much more marketable than any average secondary school graduate. Nevertheless, these secondary school graduates certainly could find employment after graduation. For example, in 1973, 72% of all U.S. jobs were held by people who had a high school diploma or less, while in 2020, it is expected that nearly two-thirds (65%) of all jobs will require some form of postsecondary education (Foorahar, 2014). The required skill sets for being employed have changed, though. Today, specific skill sets geared towards the ability to analyze big data are of paramount importance, regardless of primary job discipline.

In fall 2016 LinkedIn™ published a list of the ten most important job skills that employers around the globe are actively seeking in current job applicants. All ten positions were closely related to careers that are heavily weighted towards data manipulation, data mining, and statistical analysis. The top three positions in order on the list were cloud and distributed computing, statistical analysis and data mining, and web architecture and development framework, respectively (Smith, 2016).

The curriculum in most state STEM programs do not include standards and benchmarks for data manipulation, mining and analysis. In the 1950's a course in statistics was rarely taught in the high school classroom, but during this decade the efforts in making statistics a part of the school

REFERENCES

- Andersen, L., & Ward, T. J. (2014). Expectancy-value models for the STEM persistence plans of ninth-grade, high-ability students: A comparison between Black, Hispanic, and White students. *Science Education*, 98(2), 216-242.
- Baglin, J., Bedford, A., & Bulmer, M. (2013). Students' experiences and perceptions of using a virtual environment for project-based assessment in an online introductory statistics course. *Technology Innovations in Statistics Education*, 7(2).
- Bailey, B., Spence, D. J., & Sinn, R. (2013). Implementation of discovery projects in statistics. *Journal of Statistics Education*, 21(3).
- Bargagliotti, A., & Groth, R. (2016). When mathematics and statistics collide in assessment tasks. *Teaching Statistics*, 38(2), 50-55.
- Bargagliotti, A. E., Jacobbe, T., & Webb, D. (2014). A Commentary on Elementary Teacher Preparation to Teach Statistics. *Issues in the Undergraduate Mathematics Preparation of School Teachers*, 4.
- Bebermeier, S., & Reiss, K. (2016). Practicing statistics by creating exercises for fellow students. *Teaching Statistics*, 38(2), 40-44.
- Ben-Zvi, D., & Garfield, J. (2008). Introducing the emerging discipline of statistics education. *School Science and Mathematics*, 108(8), 355-361.
- Blagdanic, C., & Chinnappan, M. (2013). Supporting students to make judgements using real-life data. *Australian Mathematics Teacher; The*, 69(2), 4.
- Bradstreet, T. E. (1996). Teaching introductory statistics courses so that non-statisticians experience statistical reasoning. *The American Statistician*, 50(1), 69-78.
- Bradstreet, T. E., & Palcza, J. S. (2012). Digging into data with graphics. *Teaching Statistics*, 34(2), 68-74.
- Browning, C., Goss, J., & Smith, D. Statistical knowledge for teaching: Elementary preservice teachers. In K. Makar, B. de Sousa & R. Gould (Eds.) *Sustainability in statistics education. Proceedings of the Ninth International Conference on Teaching Statistics (ICOTS9, July 2014), Flagstaff, AZ, USA.*
- Callaert, H. (2000). Amazing graphs. *Teaching Statistics*, 22(1), 25-27.
- Callingham, R., Carmichael, C. & Watson, J.M. (2016). Explaining student achievement: The influence of teachers' pedagogical content knowledge in statistics. *International Journal of Science and Mathematics Education*. 14, 1339-1357.