

TECHNOLOGY-RICH PROJECTS IN ELEMENTARY STATISTICS

Dianna J. Spence
North Georgia College & State University
Dahlonega, GA 30597
djspence@northgeorgia.edu

Brad Bailey
North Georgia College & State University
Dahlonega, GA 30597
bbailey@northgeorgia.edu

Introduction

Technology helps promote many forms of meaningful learning in the context of discovery projects assigned in our introductory statistics course. Two such projects are assigned to students in the course; one is a t-test project and the other is a linear regression project. During each assigned project, students choose their own research topic, define their variables, articulate their research question, devise and carry out a data collection plan, conduct the appropriate analysis on the data, and prepare both a written report and an oral presentation to share the results with the instructor and the rest of the class. Students may work individually or in small teams of 2-4 people. These are referred to as discovery projects because the research topic is selected by the student(s), and the full project implementation is student-directed, with guidance from the instructor kept to a minimum. For both types of projects, the three phases that rely heavily on technology are the data collection phase, the data analysis phase, and the dissemination phase.

Before describing these three project phases and the technologies supporting each one, we briefly explain the rationale for using such projects in a statistics course, as well as the setting in which these projects have evolved and in which their impact has been assessed. Researchers and educators alike have consistently proposed that in courses where students conduct their own authentic statistical research, students will experience deeper learning and develop more positive attitudes about statistics (e.g., Bryce, 2005; Mvududu, 2003). However, in spite of the increasing support for such projects as sound pedagogical tools for teaching statistics, many instructors still do not incorporate projects into their statistics courses (Landrum & Smith, 2007).

These findings were the basis for the development of curriculum materials to help instructors and their students implement discovery projects (Spence, Sinn, & Briggs, 2009). These materials were developed with the support of two grants from the National Science Foundation. These grants funded not only the curriculum development, but also research into the impact of discovery projects, both on student learning outcomes and on student attitudes about statistics. In all stages of this ongoing research, each participating instructor has first taught a control section (in which such projects were not assigned). Each instructor has then taught a treatment section, in which discovery projects were

used, facilitated by the curriculum materials described. Initial results suggest that using such projects has the capacity to improve student outcomes in a statistics course. However, these improvements were found to vary significantly among different instructors and among different types of students (Spence, Sharp, & Sinn, 2011). Additional research is in progress to identify the nature and potential sources of these variable outcomes.

Technology for Each Project Phase

For both the t-test and the linear regression project assignments, technology is integral to the data collection, data analysis, and dissemination phases. Each phase is discussed below, along with a spectrum of technology options that facilitate each one.

Data Collection

During the data collection phase, students may gather data from one of three sources: constructing and administering surveys; measuring and/or recording physical phenomena; or accessing Internet data repositories. A number of tools are available to help students create and administer online surveys. These include SurveyMonkey, Zoomerang, KwikSurvey, and Google Docs Survey Maker. Students using these and other similar tools are also able to leverage the software's capability of organizing the survey results directly into a spreadsheet.

Students measuring and recording physical phenomena can use a variety of technological devices to perform the desired measurements. The simplest of these could be a stopwatch app on a smart phone. More sophisticated examples include the Texas Instruments CBL™ or CBR™ data collection systems with probes to measure such variables as temperature, light, or motion; these devices can be used with the TI-83/84 family of calculators. Finally, students occasionally have access through a science course to more specialized lab equipment for measuring a variety of variables, from the density of bacteria in a sample of water to the intensity of UV radiation in various locations of interest.

Finally, the Internet can be a virtual goldmine of rich data sources for student projects. There are databases and web pages featuring a plethora of resources, including sports data, government records and census data, nutritional information, consumer product specifications and ratings, and data on individual cities and states. When projects are introduced to the class, students are shown several examples of Internet data sources, which are instrumental in helping student groups brainstorm about topics and research questions. For example, if a student group is interested in sports, they can access one of many sports websites with extensive current and historical databases, such as <http://mlb.mlb.com/stats/sortable.jsp> or <http://www.nfl.com/stats/player> for major league baseball data or professional football data, respectively. Groups that are interested in health and nutrition may visit websites with a nutrition facts page, hosted by many of the major restaurants, fast food chains, or specialty chains that post such information online, such as <http://www.rubytuesday.com/assets/menu/pdf/informational/nutrition.pdf>. Other

student groups interested in regional trends may use <http://www.city-data.com/>, where data are available on the large cities, midsize cities, and small towns in all 50 states. These data include overall population; population proportions by gender, age, education level, marital status, and so on; median age; median income; median home price; and many other data points of interest for each city and town. Other data of this sort can also be found directly from various city, county, state, and federal government records websites, including the census bureau at <http://www.census.gov/>.

Data Analysis

The results are produced during the analysis phase of the project, after the data are collected and organized. The requirements for each project depend in part on what type of test or analysis is being conducted. The projects described here are either t-tests (2 independent samples or matched pairs) or linear regression, both of which are routinely taught to students in these elementary statistics classes. Regardless of the type of analysis required for a given project, students must produce the appropriate descriptive statistics, including graphical representations (e.g., histograms) of the distribution of their sample data. For t-test projects, students must compute and interpret the t statistic and p-value for the test. For linear regression projects, students must create a scatter plot and a graph of the regression line; they must also compute and interpret the value of the correlation coefficient r , coefficient of determination R^2 , and equation of the regression line.

Students will use one or more technological tools to accomplish these analyses, and there are many such tools available. All of the analyses described can be performed with the TI-83/84 family of calculators. Microsoft Excel also supports all of the analysis functions described, even without installing the statistical analysis add-in package. The requirements of the linear regression project lend themselves particularly well to Excel. There are also some other advantages to using Excel: 1) The program is widely accessible to students from most platforms; 2) learning basic skills in Excel can prove useful for students in a broad variety of settings, which may enhance student motivation; and 3) the charts and graphs created in Excel port easily into student papers and presentations, as noted in the discussion below, under *Dissemination*. Sometimes students use a combination of technologies for the project; for instance, a common approach is for students to organize their raw data into an Excel spreadsheet, which they then use to compute descriptive statistics and histograms. Then they use Other viable tools for performing these analyses include SPSS, SAS, Minitab, R, and the TI-Nspire. Several web-based tools for statistical analyses are also available at no cost, including those on sites such as <http://easycalculation.com/> and <http://www.graphpad.com/quickcalcs/>. Packages that accompany some statistics textbooks, such as StatCrunch or CrunchIt, can also be used. Productive use of such technology is at the heart of this project phase, which can be completed using any tools that instructors are comfortable supporting or teaching their students to use.

It should also be noted that the statistical analysis required for these projects need not be limited to t-tests and linear regression. For instance, students may also learn how to conduct an ANOVA or a chi-square test during a statistics class, depending on the

instructor's preferences and the scope of the course. Project requirements can easily be defined to align with the details of these analyses, and the technology options named above are still a good fit for such projects.

Dissemination

When the students have collected and analyzed their data, the last phase of the project is to prepare a written report and in-class presentation. Most frequently, students choose to use Microsoft Word and PowerPoint for these two tasks. Both packages are familiar and widely available, and they lend themselves to the task especially well when Microsoft Excel was used for the data analysis, since graphics generated in Excel import easily into both Word and PowerPoint, and all three of these Microsoft Office programs share a "common look and feel".

However, students are not restricted to the Microsoft Office suite for this phase of the project. Some students have used the word processor and/or the presentation package built into the web-based Google Docs package. Others have used the Adobe software suite to create documents and/or Acrobat presentations. Still others have used the Prezi presentation tool available online at no charge to students and teachers (<http://prezi.com/>). There are several advantages to encouraging students to choose their own technology for dissemination. Giving students many choices helps them to take greater ownership of their projects. Further, when students give their presentations, it is both refreshing and instructive for the class to observe a variety of formats.

Curriculum Materials

The focus of this paper has been to describe the pervasive and fundamental role of technology in discovery projects for elementary statistics. However, the curriculum materials described previously provide detailed directions and resources for instructors and their students to carry out such projects (Spence, Hix, Bailey, Cooper, & Sinn, 2012). The materials include an *Instructor Guide*, *Student Guide*, and *Statistics Project Technology Guide*, all of which are available as viewable or printable PDF files online at <http://faculty.northgeorgia.edu/DJSpence/NSF/materials.html>. The *Instructor Guide* provides a full description of the project phases with best practices for managing student progress, as well as suggested project timelines, project planning forms, formal project proposal assignments, and project scoring rubrics. The *Student Guide* provides guidance on navigating each step of the project, including translating informal project ideas into appropriate variables and research questions; tips for finding and collecting data, including survey constructs and Internet data sources; project task checklists and report outlines; and sample student projects. The *Statistics Project Technology Guide* gives step-by-step guidance with screen images to organize and analyze data for t-test and regression projects, both in Microsoft Excel and on the TI-83/84 family of calculators. The authors encourage other statistics instructors to employ similar projects in their own courses. Interested readers are invited to use these materials, either in their current form or as starting points for developing other project materials customized for their needs.

Conclusion

The technology required to implement these projects can be selected to align with the technological culture of any instructor's department or institution. Many technological tools can be used in the completion of these projects to foster meaningful statistical research experiences for students. Given the latitude to define and carry out their own research, students are often motivated and engaged throughout the project. The result is an experiential learning process that integrates critical thinking, technical writing, and presentation skills into an analytical course. Technology is leveraged to facilitate these projects, thereby helping students learn the material—ultimately, there's no better reason.

Acknowledgements

This work is supported by NSF grant award DUE-1021584. Any findings or recommendations presented in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

References

- Bryce, G. R. (2005). Developing tomorrow's statistician. *Journal of Statistics Education [online]*, 13(1). URL: www.amstat.org/publications/jse/v13n1/bryce.html
- Landrum, R. E., & Smith, R. A. (2007). Creating syllabi for statistics and research methods courses. In D. S. Dunn, R. A. Smith, & B. C. Beins (Eds.), *Best practices for teaching statistics and research methods in the behavioral sciences* (pp. 45-57). Mahwah, NJ: Lawrence Erlbaum.
- Mvududu, N. (2003). A cross-cultural study of the connection between students' attitudes toward statistics and the use of constructivist strategies in the course. *Journal of Statistics Education [online]*, 11(3). URL: www.amstat.org/publications/jse/v11n3/mvududu.html
- Spence, D. J., Hix, S. L., Bailey, B. S., Cooper, T. E., & Sinn, R. (2012). *Discovery Learning Projects in Introductory Statistics: Curriculum Materials*. URL: <http://faculty.northgeorgia.edu/DJSpence/NSF/materials.html>
- Spence, D. J., Sinn, R., & Briggs, K. (2009). Authentic discovery projects in elementary statistics. In J. Horn (Ed.), *Engaging approaches: Proceedings of the 7th annual teaching matters conference* (pp. 107–115). Barnesville, GA: Gordon Publications.
- Spence, D. J., Sharp, J. L., Sinn, R. (2011). Investigation of factors mediating the effectiveness of authentic projects in the teaching of elementary statistics. *Journal of Mathematical Behavior*, 30, 319-332.