A Project-Based Elementary Statistics Course

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The following paper discusses the use of real-life data projects in two elementary statistics classes. One class worked on projects geared specifically toward students' major fields of study and the other worked on a more comprehensive project based on data from local industry. Pedagogical issues addressed include innovative teaching practices (cooperative learning and working as a partner with local industry); catering for various learning styles (hands-on laboratory work and on-site visits); and developing dynamic curriculum (topics emphasized depend upon the needs of the cooperating business and also on the interests of the students).

Introduction

Most colleges and universities in the United States have an elementary statistics course included in their offerings for undergraduates. Kent State University (KSU) statistics faculty members have focused on the interpretation of statistical concepts by emphasizing statistical thinking using real-life data. This paper studies the effect on student attitude and achievement of working in cooperative groups on real life projects in such classes. Two different situations are studied; each employing a different type of project. In one class, students worked on self-selected projects that related directly to their major, and in the other, students worked on a single project using data from a local industry. In the latter case, the students acted as consultants and reported their findings to the company. Emphasis in the paper is on the innovative use of projects and how they can be tailored to different learning styles of students and effect dynamic curricular change. Data in the analyses include comparison of grades and the results of student attitude surveys.

Student Selected Projects

At Kent State University students are introduced to statistics through the course *Elementary Probability and Statistics*. The nature of the course and student body at our regional campuses creates a diverse classroom population. We hoped to improve the "take-home" value of our elementary statistics course by assigning projects in which students worked on real-life problems of their own choosing. Balancing the needs of these various diverse groups has been a great challenge.

Meeting the Needs of a Diverse Student Population

It is strongly recommended that students in many major fields of study (Nursing, Criminal Justice, Education, Fashion Designing, and Education) take this course as an elective. On average,

the distribution of students in this course by their major is as follows: Nursing - 48%, Criminal Justice - 12%, Education - 12%, Fashion Design - 9%, Science - 7%, and Social Science - 10%. The open enrollment policy of the branch campuses of Kent State (such as KSU Stark) creates a natural diversity in the classroom with poorly prepared students and well-prepared students sharing the same classroom. Another type of diversity exists and is a direct consequence of KSU Stark's role as a commuter campus. Here the diversity is between traditional and non-traditional students. Non traditional students are defined as students who are at least 21 years old and will have graduated from high school three or more years prior to enrollment as college freshmen. The traditional group are largely technologically proficient, while the non-traditional student body generally consists of older students with industrial experience who want to learn statistics as a relevant tool for applications to their work environment. The use of statistical software (such as in *SPSS*, *Minitab*, the TI-Calculators, MS *Excel*) eliminated the laborious calculations involved in these projects, which were chosen to peak the interest of students in diverse major fields of study. Although we were in fact creating small homogeneous clusters based on interests, there still remained diversity within each group (traditional/non-traditional, well prepared/poorly prepared). We took into consideration several factors that control the dynamics of the classroom including a very careful assignment of group membership for collaborative in-class activities. Information was gleaned from student records and the 'Student Information Sheet' completed by students at the beginning of the course.

Mini-Projects

Despite all good intentions, after one semester of requiring the students to complete an end-of-semester project, it became clear that changes were in order. Comments made in the student evaluations and during informal conversations during the course of the project indicated that student satisfaction was low and expectations were not met [Table 1]. There were some successful projects, however. Perhaps in a more advanced course, conditions would be more conducive for well-written projects ([1], [2]) with little teacher intervention. Could we reasonably expect the same from students enrolled in an elementary course?

Semester	**Student Comments on "projects"**
Spring 96	Expectations were not specified. Not enough guidance. No sample project to refer to. Project not relevant to major. Not fair to group by major – nursing majors have an advantage.
Spring 97	Mini-projects should relate to real-life more. Should meet three times during the week instead of twice, thus giving more time for computer work.
Spring 98	Introduction to computer lab should be done sooner. Mini-projects were very helpful. Give out main project sooner. Let students know in advance the requirement of a TI calculator and knowledge on MS Excel.
Fall 98	Introduction to TI calculators and MS Excel was useful. Projects related to the major well. Projects were interesting. Good applications of concepts via mini-projects.

Table 1: Selected Student Comments

Note the gradual evolution of student comments regarding the relevancy of the projects. We addressed the complaints of project relevancy and the Nurses' advantage due to their large numbers by offering a wider variety of choices of topics that spanned all majors (with more

choices in Nursing). The problem still remained, however, of requiring elementary statistics students to complete a sophisticated study - a seemingly overwhelming project to those not comfortable with the "unexpected road bumps" they encountered. It is not sound practice to let a would-be bungee jumper swoop down for the first time before being cured of vertigo. The use of mini projects gradually prepared students to take on greater tasks. Approaches similar to ours have appeared in the literature, for instance in [3]. Evaluations in the subsequent semesters [Table 1], after the introduction of mini-projects, showed an increase in both student satisfaction and the quality of the final reports.

Summarizing then, we introduced mini-projects:

- To increase student motivation (expecting improved performance and better retention).
- To encourage collaborative learning.
- To reinforce concepts discussed in class.
- To prepare students for the end-of-semester project through resourceful use of technology.

The mini-projects are concept-based, while the end-of-semester projects are based on the students' major fields of study. Excellent sources for mini-projects can be found in [4], [5], [6].

The students have nearly two months to complete the end-of-semester project. They work in cooperative groups (i.e. with students of similar majors), though each student submits an individual final report. Students will sometimes augment these reports with an in-class presentation using posters and overheads. Examples of end of semester projects include: *Weights of Newborn Baby Girls*, (Nursing), *What Do S.A.T Scores Tell Us?*, (Education), *Measurement of Atmospheric* CO_2, (Sciences). The best-written project reports are submitted for refereed publication in the annual *Writing Center Review*, a publication that showcases selected essays by students of KSU Stark.

Outcomes

We were primarily interested in measuring two student outcomes. First of all, we were interested in attitudes concerning the effects of both the end-of-semester projects and the mini-projects on learning. The data collected from the four semesters indicated positive results on both counts. Secondly, we were interested in knowing if non-traditional students (who are largely under-prepared upon entering) performed well in this course. The data shows that their average grades were *very close* to the class average [Table 2]. The *quality* of their final reports followed a similar pattern. The performance of non-traditional students was up to par in this collaborative setting.

	Traditional	**Non-traditional**
Enrollment (average percentage, total = 56)	68% (38/56)	32% (18/56)
Grade in Class (average GPA, 0-4 scale)	2.83 $\sim$ B–	2.80 $\sim$ B–

Table 2: Comparison of Traditional verses Non-traditional Students

The J.W. Harley Project

Four students from two elementary statistics classes participated in a one-credit hour special project course involving analysis of data from J.W. Harley, Inc., a local re-manufacturing firm. A Company manager explained the project to the students, who then toured the plant. The students met once a week in the computer lab to work with the data, and at the end of the semester they reported their findings to the company. Students prepared both an oral report and a written technical report. Statistical concepts involved paralleled those that the students were studying in their twice-weekly statistics class.

Project Description

Students received data from J.W. Harley Company of Twinsburg, Ohio - a company that re-manufactures air compressors and parts for electric utility companies. The data involved infrared emission readings at 22 locations on each of four different models of compressors. Tests were conducted with the compressors on an open test stand with the compressors contained in a metal "house." Students received 257 test results and were to note any significant patterns in the readings and create new upper and lower control limits for the readings at each location.

Innovative Teaching Practices

Students worked as a team for the duration of the semester, depending upon one another not only for computer work but also in the compilation of a single final report. Initially they received raw data and decided themselves how to divide the work for efficient completion of the project. Though each student analyzed a particular set of data readings, they needed to come together for the final report. They compared findings and charts. The instructor provided direction only as needed and when questions arose. Such student-student collaboration did lead to some frustration, however, as some students didn't follow through with meeting attendance or deadlines for completion of work. However, the end result was positive; the students became a unit, wanting to meet even after the semester was over in a social setting.

Students worked with real-life data from a local company and acted as consultants. On-site visits were an integral part of the students' experience, one that students found helpful. The quality control personnel of J.W.Harley were interested in the students' findings and planned to use their results in future testing. The students found this aspect of the project most beneficial. When asked at the end of the semester if the project changed their perception of statistics, all four made positive comments about it increasing their awareness of the usefulness of statistics in the real/business world.

The class was offered as a one credit hour supplement to the Introductory Statistics class. In this way, students received the extra credit hour they earned for the amount of work such a project entails. Real world projects tend to be messy and ill-defined which can result in both students and instructor spending an incredible amount of time – perhaps more than is appropriate for a routine course with its normal assignments and exams.

Catering to the Learning Styles of a Diverse Group

The four students involved in the project were quite a diverse group with different learning styles. Jackie, a freshman accounting major, was uncomfortable at times with the exploratory nature of the project and seemed to prefer the more familiar teacher-directed format (i.e. the lecture method). According to the learning style model formulated by Felder and Silverman [7], Jackie's learning style was deductive and sensory. A deductive learner prefers a structured presentation; a sensory learner favors information coming through their senses as opposed to that which arises internally (memory, reflection, and imagination). Mike, a junior geology major thrived on the very aspect that Jackie disliked. He thoroughly enjoyed the project, volunteering twice to speak at a departmental Open House about it. He was also the natural leader of the group, being the principle speaker at the oral presentation at Harley. His analysis showed a fine grasp of statistical concepts as well as of compressor operation. Mike was an inductive learner, preferring to see specific cases and then making generalizations by inference. He also appeared to be a bit more intuitive than the others. Ken, a senior who lacked confidence in mathematics at the beginning of the semester, felt comfortable with the software and made

significant contributions. At the end of the project, he described his own math ability as being higher than at the beginning of the semester (3 on a scale of 5 as opposed to 2 of 5 at the beginning). Ken appeared to thrive on the hands-on nature of the project - evidence, perhaps of his preference of a sensory learning style. Terje, a mature mathematician and graduate student, was better able to handle the uncertainty of exploratory analysis with more patience than her undergraduate counterparts.

Table 3 shows a summary of comments made by each student in the experimental group. The positive responses seem to indicate that the learning needs of students were met.

Student	**Comments**
Freshman	Standard deviation is clearer to me ... correlation is clearer.
Senior	It helped me understand graphs, ... box-plots, line-plots, and histograms.
Junior	This project elucidated several concepts. First the H_0 (null hypothesis) and also charts and graphs.
Ph.D. student	It helped me to recall many concepts because it has been at least 5 years since my last stats course.

Table 3: Student Comments Concerning Their Understanding of Statistical Concepts as a Result of Working on the Harley Project

Felder made several recommendations for meeting the learning styles of undergraduate science students. In order to meet the needs of *sensing, inductive*, or *global learners*, he suggested motivating the presentation of theoretical material with the prior presentation of problems or phenomena that the theory will help solve or explain. The Harley Project did just that. Students were presented a real-life problem (find new upper and lower control limits, determine if a process is in control) as they studied descriptive statistics and graphical summaries but before they studied the Central Limit Theorem and hypothesis testing. For *sensing* learners, Felder emphasized balancing concrete information with the conceptual. Again, the Harley temperature readings, coupled with on-site visits to the factory certainly fulfilled this recommendation. For visual learners, he emphasized the use of sketches, plots, and computer graphics; the students made extensive use of the software *ActivStats* in their analysis of the Harley problem. Felder encouraged numeric examples for the *sensory learner*, experimental observations before presenting general principles for the *inductive learner*, class time for active student participation for the *active learner* and cooperative learning. The Harley project provided these opportunities to meet the needs of various learning styles.

Dynamic Curricular Changes

The J.W. Harley project is an innovative course focusing on a modern data analysis approach to elementary statistics. Students work with interactive visual tools to discover and describe patterns in various data sets. They begin with the data in context and learn to choose and use appropriate techniques as needed within that context. Writing, communication and critical thinking are stressed. The course utilizes a laboratory approach to learning as students work in a collaborative setting. Each group analyzes real world data from a local industry and plans, implements and communicates their results both in written word and oral form. On-site visits to the company are an integral part of the students' experience and were welcomed by students and company personnel alike. The nature of such a course demands flexibility and is in continual development from semester to semester since its content depends upon the current needs of the cooperating business.

Though enrollment in the Harley project course was small, such limitations were the result of recruitment issues rather than course design. The course was planned for a full class composed of several small groups of students. Each group would work with the same data all semester, then contrast and compare their results to those of the other groups. Discussions between groups about data analysis techniques chosen, modifications made during the course of the semester, as well as final results would certainly have enriched the educational experience of the students.

Conclusion

Real world projects in an elementary statistics course encourage active student participation and result in positive attitudes toward the subject itself and a better understanding of its usefulness. Allowing students some choice in determining topics of study as well using mini-projects motivates quality student work. Our students welcome an innovative learning/teaching environment such as being consultants for a local company, on-site visits, collaborative learning, extensive use of software and working on projects geared to major fields of study.

References

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