Project-Based Learning in a Statistical Quality Control Course

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Abstract

Due to the different ways in which students learn, professors must vary their teaching styles. This variation in teaching styles will aid students in their understanding of course materials and enhance student learning. Richard Felder, a leading scholar in the area of learning styles reports, "Students preferentially take in and process information in different ways: by seeing and hearing, reflecting and acting, reasoning logically and intuitively, analyzing and visualizing, steadily and in fits and starts."

Project-Based learning (PBL) is an innovative teaching methodology available to teachers to provide student a different type of classroom experience. PBL is designed to make learning relevant and useful to students though the establishment of connections outside of the classroom. This style of teaching changes the relationship between teachers and students. It focuses on the central concepts and principles of a discipline, involves students in problem-solving investigations, and allows students to work autonomously, to integrate concepts across disciplines, to apply principles to real life scenarios, and situations and practices.

This article looks at the incorporation of PBL into a Statistical Quality Control Course. The incorporation of projects synthesizes information that the students have been presented via formal/traditional lecture. Also the use of projects serves to solidify and expand students' understanding of the covered material.

Introduction

The need for change is rapidly sweeping through institutions of higher education with remarkable speed. The traditional teacher-centered approach to learning is rapidly being replaced by a student-centered approach to learning. Faculty members are not only being asked to develop the intellectual, technical, analytical and problem solving skills of their students, they are being asked to engage students and motivate them to learn on their own.

The primary functions of the faculty member in the teacher-centered approach are to lecture, plan assignments and tests, evaluate performance and assign grades. Whereas, in the student-centered approach these same functions exist however the faculty member is also encouraged to actively involve the student is his/her learning[1]. Student-centered approaches to learning are often facilitated through active learning. Active learning occurs when students do more than listen during class. Active learning is accomplished through challenging students to ask and answer questions, incorporating problem solving exercises and projects into the course, and students engaging in small discussion in and out of class[2].

Project-Based learning (PBL) is a technique that encourages the involvement of students in their learning experience. PBL is an innovative teaching methodology available to teachers to provide students with a different type of classroom experience. PBL is designed to make learning relevant and useful to students through the establishment of connections outside of the classroom. The use of PBL in the classroom changes the relationship between faculty members and students. It focuses on the central concepts and principles of a discipline, involves students in problem-solving investigations, and allows students to work autonomously, to integrate concepts across disciplines, to apply principles to real life scenarios, and situations and practices.

Furthermore, Project Based Learning allows students to: develop their own ideologies regarding topics and issues; work on relevant topics that are of interest; shift the focus of instruction from memorization to idea exploration and incorporate previous experience into the solution. The benefits associated with project-based learning include:

- a reduction in competition between students.
- impart the skills and strategies associated with planning, carrying out, monitoring, and evaluating a variety of intellectual investigations, including problem solving, designing, decision making, performing experiments, and making value judgments
- create a climate within which students can learn and practice a variety of "learning to learn" skills and dispositions (e.g., skimming and note-taking, questioning, listening)
- the development initiative, persistence, and autonomy amongst students.
- the integration make learning meaningful by integrating concepts across subject-matter areas link cognitive, social, emotional, and self-management goals just the way these goals are linked in real life

The Project

A key aspect of project-based learning is the selection of the projects to be assigned. Projects should be open-ended and complimentary to the curriculum. Furthermore, the faculty member should provide a clearly defined objective and adequate background information.

The following five characteristics adapted from Steinberg's six A's of Designing projects can serve as a guide for faculty members[5]. At the time the projects are assigned students should also be furnished with guidelines for presenting their work as well as the criteria by which they will be graded.

Table 1. The A's of Designing Projects

Authenticity	• Does the project emanate from a problem that has meaning to the student? • Is it a problem or question that might actually be tackled outside of the classroom?
Academic Rigor	• Does the project lead students to acquire and apply knowledge central to one or more discipline or content areas? • Does it challenge students to use methods of inquiry central to one or more disciplines?

	• Do students develop higher order thinking skills and habits of mind?
Applied Learning	• Does the learning take place in the context of a semi-structured problem, grounded in life and work in the world beyond school? • Does the project lead students to acquire and use competencies expected in high performance work organizations (e.g., teamwork, appropriate use of technology, problem solving and communication)? • Does the work require students to develop organizational and self-management skills?
Active Exploration	• Do students spend significant amounts of time doing field-based work? • Does the project require students to engage in real investigations, using a variety of methods, media, and sources? • Are students expected to communicate what they are learning through presentation and/or performance?
Assessment	• Do students reflect regularly on their learning using clear project criteria that they have helped to set? • Do entities from outside the classroom help students develop a sense of real world standards for this type of work? • Will there be opportunities for regular assessment of student work through a range of methods.

The Course

At the University of Nebraska-Lincoln, project based learning has been incorporated into a traditional Industrial Engineering course, Introduction to Statistical Quality Control (SQC), IE 421/821. IE 421/821 is a cross-listed undergraduate/graduate course typically taken by junior and senior Industrial and Mechanical Engineering students. It is a required course for IE students and a technical elective for ME students. For graduate students it can be required or an elective depending on the focus area of the student. The prerequisite for the course is IE 321, Applied Engineering Probability and Statistics. The course is typically offered in the Spring Semester. The purpose of IE 421/821 is to introduce student to the concepts of quality improvement and statistical quality control. The objectives of the course are shown below:

- List and explain the philosophy and basic concepts of Quality Improvement in the Modern Business Environment.
- List and explain the philosophy and basic concepts of Statistical Methods useful in Quality Improvement; Statistical Process Control, Process Design and Improvement with Designed Experiments, and Acceptance Sampling.
- Design, apply and evaluate statistical process control systems, designed experiments, and acceptance sampling.
- Apply technology to the design and interpretation of Quality Control Problems.

Projects

In order to achieve the aforementioned fourth goal group projects were added to the course. The projects involved the collection and analysis of data using a device called a Statapult designed by Air Academy Express. A pictu hown in Figure 1.

Figure 1. Statapult

The statapult was selected because of its versatility. It can be used to solve a number of different problems. The projects selected were used to support lecture material on the following topics:

- Variation
- Control Charts
- Design of Experiment

A project example is shown in Figure 2. In future offerings of this course 2 additional projects will be added. Labs will be added to assist with the following area: quality management tools and repeatability and reproducibility.

Each project provided practical applications to the concepts covered in lecture, homework and exams. The addition of projects provided students yet another venue in which they could demonstrate their proficiency with course material.

Conclusions

Project based learning can be a tremendous asset to faculty members. The author believes that project based learning can provide a wonderful learning experience for students. Projects encourage the development of problem solving skills, foster collaboration and allow for the synthesis of multiple topics and skills. Students find projects a beneficial and rewarding addition to the course. The following statements regarding students' experiences with project-based learning were shared during small focus groups with former students or via course evaluations:

> "The project component of IE421 helped me to better apply the theories and concepts presented during lecture."

"I feel that the statapult experiment was a good learning experience since it helped us learn the text book material in a better and faster way. And it was also a very good opportunity to see how the theory that we learned in class was applied to a real life situation. Since we were dealing with real data I felt more motivated to read the book and be prepared to perform the experiment. It was also fun to fire the balls and measure distances and also to actually observe the variations. Even though the textbook spoke about all the variations it was always a good feeling to actually see for our selves and believe it. I Felt wide-awake and energetic while doing the project as opposed to being a passive listener in class. Performing the experiments, made it easier for us to remember what we learned since we knew precisely what each of us did. This also helped us in remembering the theory, even some of the formulas. It was also fun to work in teams. When we were performing the experiments all members participated actively but when it came to writing reports not all members participated equally. Just as in any other team there were a few free riders. But overall, I feel that this method of learning via project work is an effective method since the learning experience becomes enjoyable and is much faster."

Introduction to the Statapult

PROJECT 1
Variance Reduction

This is a two-part exercise that emphasizes the importance of variance reduction in a process.

Part I
Each student on your team is to fire the ball 10 times and record the distance the ball travels on a check sheet (which your team should develop). You should use 170^o as the start angle and 90^o as the stop angle. You should also use the following settings for the other items:

Cup Position	1
Tension Pin	4
Rubberband Hook	5

Assignment
After firing the ball your team should do the following:
A. Construct a run chart and a histogram for your data.
B. Construct flow chart for the process of firing the statapult.
C. Draw a cause and effect diagram on the things that impact the distance the ball travels. (Refer to our lecture on quality tools)
D. Based on your flow chart and the cause and effect diagrams develop Standard Operating Procedures (SOP) so that anyone firing your firing process produces consistent results.

Part II
Using your SOP, each member should fire the Statapult again and record the data.
A. Construct a second run chart and histogram for the new data.
B. Compute means and standard deviations for both sets of data.
C. Conduct statistical tests on the means and variances and draw conclusions about the two processes.

Figure 2. Project Example

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