A Class Project Experience in a Sophomore-Level Design and Manufacturing Course

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Abstract

Problem-Based Learning (PBL) has been hailed in education literature as the epitome of active learning\textsuperscript{1-4}. Driven with this conviction, the authors introduced a hands-on, plus computer, project in a sophomore-level design and manufacturing course. Here, the authors present their experience with this Problem-Based Learning experiment. They provide an evaluation of the educational experiment and any lessons learned or future recommendations. Depending on available resources, interested design and/or manufacturing teachers can adapt a similar project description for their own courses.

Introduction

In the realm of engineering and science education, finding diverse and effective ways of presenting the technical concepts of abstract material has been challenging. Problem-Based Learning encourages unique individual approaches to these complex concepts by having students solve open-ended problems. Without strict procedural guidelines, students are free to approach the problem by whatever means most suited to their learning style, while acquiring the research and development skills associated with the problem statement. The complete problem statement used by the authors is included in Appendix I.

The authors instructed a sophomore-level active learning-based design and manufacturing course at the University of New Mexico. The material in this course bridged concepts and theory with application from previous coursework, such as 3-Dimensional computer aided design (CAD). The Mechanical Engineering Department takes students through a five-course design sequence where this course is second. The hope is that with more design exposure and experience the University will produce better engineers. In conjunction with this design experience, students also developed the necessary communication skills to be an effective team member\textsuperscript{4}.
Students were assigned to groups for both in-class and laboratory assignments. The forty students enrolled in the course were divided into ten groups of four according to their grade point average (GPA). Students with higher GPAs were grouped with lower GPAs such that the average group GPA was 3.09 on a 4.00 scale. The method the authors used to determine groups is outlined in Tables 1 and 2. Table 1 lists the students and their corresponding GPA. Table 2 displays the division into groups and the average GPA of each group.

Table 1  Student Sorting According to GPA

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The purpose of this division technique was to study the outcome of group performance using the peer-rating system similar to that implemented by Kaufman et al.\textsuperscript{5}. The peer-rating system requires each group member to evaluate his/her teammates as well as themselves per the peer-rating sheet included in Appendix II. Each rating was converted into a numerical grade based on the system demonstrated by Kaufman et al.\textsuperscript{5}, where each rating from Excellent (100 percent) to No Show (0 percent) decreased by 12.5 percent increments. Using the calculated individual average from Appendix II and the overall team average from Appendix I, a weighting factor is applied to distinguish an individual’s grade from the group grade. This method allowed for grades of team members within a group to vary depending on participation and work quality.

**Problem-Based Learning Experiment**

The problem statement required each student group to design and develop two office supplies of their choice. Students were limited to the resources available at the university student machine shop, which include: lathes, mills, a grinder, various metal cutting tools, measuring devices, and basic stock materials. The available stock materials ranged from rods, bars, and sheets of aluminum, copper and Plexiglas. Connective mechanisms (i.e. screws and bolts) as well as aesthetic enhancements such as paint were optional and not provided by the university machine shop.

The design and development processes required students to research office products from all aspects. Specifically, students researched cost of materials and manufacturing, including labor for their specific design in order to market their products. Students designed their office products as 3-Dimensional CAD models then built the corresponding prototypes. Partway through the allotted time given to complete the project, students submitted a preliminary marketing strategy and draft 3-Dimesional CAD drawings. This assured the authors that students were taking the time necessary to be thorough and that students were given enough time to modify their designs later if necessary. Upon completion, students displayed their prototypes and cost analysis to be judged by department administrative staff in charge of office supply purchases.

**Results and Discussion**

The marketing flyers designed by each group are located in Appendix III. The flyers demonstrate both the creativity and time put forth in designs. Students manufactured items such as pencil and business card holders, computer monitor stands, and various storage trays.

Evaluation by departmental administrative staff proved a good learning experience for the groups. On the due date, all groups met at the university student machine shop to display their designs. Most groups were very excited about their products, but were surprised and impressed with the ingenuity and creativity of their other classmates. Each display consisted of student prototypes and their corresponding marketing flyer intended to advertise the products. This was the environment set for the evaluation team in order for it to select the most useful and cost effective designs.

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The evaluating team had a set of four questions (Appendix IV) ranging from aesthetic appearance, usefulness, and cost, which they had to address for each of the ten student groups. The questions were on a 10.0-point scale with 10.0 being excellent. For grading purposes, the 10.0-point scale translated directly to a percentage scale where 10.0 corresponded to 25 percent. For each group, the scores from all evaluators were averaged to obtain a single group grade. Finally, group grades were adjusted according to peer ratings to determine individual grades.

**Lessons Learned**

As anticipated, students became familiar with many aspects of the total design process. Many groups modified designs based on cost comparison with existing products and manufacturing feasibility. This forced students to employ the critical thinking skills necessary to be successful in engineering. Learning these skills now will only benefit them in the future both in advanced design courses and ultimately in their careers.

Over the course of the semester, students were very liberal with peer rating within their groups, for example with homework assignments, and generally scored their teammates at the same levels as themselves. Conversely, the grading amongst peers was taken more seriously during this Problem-Based Learning exercise. Some group dissension was evident in peer evaluations with respect to project grades due to frustration in the team member’s prioritization of time and participation outside of scheduled laboratory time. Ultimately, the majority of group grades for the project were very close regardless of group GPA. This implies that the skill set for each group was evenly distributed for this project assignment.

The Problem-Based Learning experiment enabled students to take a design through all the steps necessary to create a viable product. It encouraged students to be open-minded and unique in their approach, while reinforcing the importance of collaboration and team effort in the engineering environment. Typically, Problem Based-Learning has not been implemented in introductory engineering courses such as this, but has helped students here to understand engineering practice outside of the classroom. The authors agree that this experience was beneficial to the students in their class.

**References**

2. Woods, D.R., 1994, “Problem-Based Learning: How to Gain the Most from PBL,” Publisher: Donald R. Woods, Watertown, ON.

JULIE KIMSAL
Julie Kimsal currently works as a graduate Teaching Assistant for the “Mechanical Engineering Design II” course in the Department of Mechanical Engineering at the University of New Mexico (UNM). Her research interests lie in the areas of solid mechanics and design, especially using finite-element analysis. Her teaching responsibilities include machine shop supervision and training. Before joining UNM, she spent five years as a design engineer in several U.S. companies.

TARIQ A. KHRAISHI
Dr. Khraishi currently serves as an Assistant Professor of Mechanical Engineering at the University of New Mexico. His general research interests are in theoretical, computational and experimental solid mechanics and materials science. He has taught classes in Dynamics, Materials Science, Advanced Mechanics of Materials, Elasticity and Numerical Methods. For the last four years he has engaged himself in the scholarship of teaching and learning.
Appendix I

Problem Statement

ME260, Fall 2005
Project
Each group/team in the class is asked to:
1- Design on a 3-D CAD system/software TWO pieces of office supplies, i.e. two products, which your company, managed by your group/team, produces as part of a line of brand name products for office supplies.
2- In the lab, i.e. student machine shop, actually make these two pieces.
3- All machining operations used in creating the pieces HAVE TO BE those currently existing in the student machine shop, i.e. it must be capabilities that our student machine shop currently has. For example, you cannot do things using home tools or go to in-town machine shops. The only exception to this rule is if you want to use some sort of glue, some sort of paint, or screws/bolts/nuts in making your products.
4- Select a brand name for your products.
5- Create an informational, colorful and attractive flyer exhibiting these two products and the brand name. The purpose of the flyer is for people to have interest in buying your products, i.e. it is a marketing tool. The flyer is a prototype for a bigger poster that can be widely distributed later on by your company to office supply stores and customers.
6- You need to try to price these products by collecting information, as much as you can, on material cost and manufacturing costs. You also need to benchmark against existing products in the market.
7- The project grade will go towards:
   a- the flyer design and attractiveness including the choice of the brand name.
   b- the care by which you actually made the two products/pieces and how professionally-done and appealing they are/look for a potential customer.
8- The project will be judged by the ME staff members (or others) who, as part of their job, have to buy office supplies for their use or the use of others.
9- You are allowed to use resources found in the student machine shop. You have to work on your project DURING the shop time (i.e. 2pm-5pm, Monday, Tuesday, Wednesday). This is when the shop will be open for your use and when the TA can give you access to existing tools/machines.
## Appendix II

### Peer Evaluation Form

**Date:** ________________

**PEER RATING OF TEAM MEMBERS**

<table>
<thead>
<tr>
<th>Name</th>
<th>Group/Team #</th>
</tr>
</thead>
</table>

Please write the names of all of your team members, INCLUDING YOURSELF, and rate the degree to which each member fulfilled his/her responsibilities in completing the homework assignments. The possible ratings are as follows:

- **Excellent**
  - Consistently went above and beyond—tutored teammates, carried more than his/her fair share of the load
- **Very good**
  - Consistently did what he/she was supposed to do, very well prepared and cooperative
- **Satisfactory**
  - Usually did what he/she was supposed to do, acceptably prepared and cooperative
- **Ordinary**
  - Often did what he/she was supposed to do, minimally prepared and cooperative
- **Marginal**
  - Sometimes failed to show up or complete assignments, rarely prepared
- **Deficient**
  - Often failed to show up or complete assignments, rarely prepared
- **Unsatisfactory**
  - Consistently failed to show up or complete assignments, unprepared
- **Superficial**
  - Practically no participation
- **No show**
  - No participation at all

*These ratings should reflect each individual’s level of participation and effort and sense of responsibility, not his or her academic ability.*

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Your signature: ____________________________

Circle one of the following:
- I am evaluating (a) Lecture Presentation
- (b) Homework (#: )
- (c) Project

Appendix III

Marketing Fliers

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The Lucky Seven Design Group

has been designing the cutting edge products in the office supply industry over the past several weeks. These sleek edgy office supplies are what every young professional needs to personalize their workspace while keeping it modern.

Why does everyone want Lucky Seven Design Group's Business card/Accessory holder? Easy........

- The business card/Accessory holder is ergonomically friendly.
- It can be used for easy access to all of your latest office accessories.
- The precision machined product's aluminum design ensures it will last a lifetime!

This business card/Accessory holder is a must have for any young professional. For questions or details, consult your nearest Lucy Seven Design Group Representative.

Why does everyone want Lucky Seven Design Group's Photo Frame Picture weight? Easy........

- It easily holds and displays photos for you to enjoy every day of the year.
- It holds papers firmly in place anywhere in your workspace.
Need Office Supplies?

$25

ME 260

Nameplates

Let us take care of it

Business Card Holders

$10

Quality metal fabricated parts at a reasonable cost.

LOBO, INC.
Come share in the joy of ergonomically designed office equipment! Experience the unrivaled comfort of working in an environment designed with your health in mind. At ergo-BUDDY, we design all of our products to provide the ultimate in comfort and style. Over time, the use of our products can help prevent workplace injuries such as carpal tunnel syndrome and bursitis.

Introducing the Monitor Riser

"It’s Adjustable"
ONLY $15.99

When just placed on a desk, almost any computer monitor will sit too low, and the user is forced to look down at it. Over time, this can cause strain in the neck and cause muscular cramps and spasms. That’s why we at Ergo-Buddy have created the adjustable Computer Monitor Riser. This strong yet lightweight monitor stand raises your monitor to the appropriate height. The Monitor Stand provides a two and a half inch lift, and comes with leg segments that can be used to increase the height of the stand. These allow the worker to customize the height of their computer monitor in order to compensate for desk elevation as well as the height of the worker.

ergonomically correct

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1-555-629-2205
www.ergobuddy.com
New from...

G-10 Office Supplies, Inc.

Business Card/Pen holder

Can hold up to four pens or pencils with your business cards in the center.

Priced at $11.95

Created by the members of Group 10

Post-it Board

When you run out space on your monitor for sticky notes, you can place them on the Post-it Board.

Priced at $3.95
When Success is Your Goal!

Sin Bin Ink

For the Hockey Lover

The Bisquit Paperweight

$20.99

- Multi-purpose use
- Eye-catching hockey puck paperweight
- Keep your documents organized with style and creativity

The Lumber Letter Opener

$5.99

- Quick Clean Letter Opening
- Durable
- Easily opens small and large envelopes
- Trendy

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Cardinal supply co.
Retro™ Software Organizer

- Cool stylish software storage for any manager’s desk
- Constructed of aircraft aluminum and acrylic
- On sale for only $29.95
- Discounts of 10% for orders over 20
- Contact: sales@coyotemfg.com or call 505-555-1235
  For additional information

COYOTE MANUFACTURING INC.
BP, Inc.

**AEROSpace Pencil Holder Blowout Sale!**

- What percentage of aircraft material is YOUR pencil holder?
- 100% Aircraft quality material!!
- Rigid industrial strength construction!
- Does your pencil holder measure up?

Sale runs for one day only! Get yours for only $19.99!

---

BP, Inc.

**The Card Possessor 5000 Clearance Sale!**

- Why have a boring card holder when you can have the multi purpose CP-5000!
- 100% Aircraft quality aluminum!
- Tandem card holding ability!
- 150 card capacity!

Sale runs for today only! Get the hottest business card holder ever, only $14.99!
Appendix IV

ME260 Project Evaluation Form

Judge Name: ___________________________________

Note1 to judges: Please keep in mind when judging that the pieces of office supplies have been hand-machined or hand-worked and not computer machined. Computer machining typically results in a much better finish and quality.

Note2: Please rate all questions below from 1 to 10, with 1 being the lowest or least weight and 10 being the highest or most weight, i.e. 10 for the best and 1 for the worst.

Group #: _______________

1. Rate (from 1-10) the attractiveness of the flier from a marketing point-of-view: _______

2. Rate (from 1-10), independent of price, how appealing the products are for you as a potential customer: _______

3. Rate (from 1-10) the care by which the two office pieces were fabricated, i.e. how professionally-looking they are: _______

4. Does the price for the pieces seem reasonable for what they are? (Rate from 1-10): _______

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