

## Effective Teaching Methods in Lower Division Engineering Programs

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### Abstract

Our teaching/learning strategy is to develop effective teaching and active learning methods for lower division engineering programs and prepare students for transferring to a four-year school successfully. One of the student learning attitudes is described as “Tell me, I will forget; Show me, I may remember; Involve me, I will understand.” It reflects the way whether students can learn effectively or not. In order to get students involved, we have developed several teaching methods for student active learning from the lectures of engineering fundamentals courses to hands-on design laboratory courses. The methods include teamwork, class/group discussion, peer tutoring/teaching, and problem solving skills. In each activity, students can be a learner or can be a teacher, to lead or to be led. It creates interaction between teacher and students. The hands-on laboratory courses reinforce the basic concepts that the students have learned from the lectures. To enhance the students’ laboratory experiences, computer-based design software has been used in the measurement and the design process. The student design projects are interdisciplinary. The projects integrate the knowledge from electrical/electronic, mechanical and computer programming. The design processes challenge students’ creativity and the ability to apply engineering principles to the design. Also the activities improve the teamwork and communication skills.

In addition to the classroom teaching/learning, the field trips to the industrial sites and the meetings with engineering professionals help students to link the real world designs and problems. The outcomes are evaluated and the assessment shows that getting students involved to the actives improves the students learning. The rate of retention and successful transfer to 4-year school is increased. In this paper, we would like to present some experience in teaching and learning in engineering education.

### Introduction

Potomac State College is a regional campus of West Virginia University. The two-year engineering program has an articulation agreement with the University. Most freshman engineering students are from the tri-state region, and they have various backgrounds. Some

students determine to pursue an engineering career by the influences from their parents, teachers and friends. Others do not have many ideas about engineering career and what preparation required by engineering program. We also have a small group of nontraditional students. They have their clear career goals. Similarly, the students have various levels of pre-college preparation. Some students passed the math placement tests, but still have difficult time in the first calculus course. Our goal is to develop the effective teaching methods to make engineering interesting to every student in the learning process, to encourage them strive for their career goals, and as well as to increase the retention rate.

## **Courses Contents**

### Freshman engineering class

At the introduction level of engineering, the first engineering course for freshman consists of two parts, the orientation and the design projects. In the orientation, students will learn engineering professional and ethics, engineering majors and careers. In the design project, we emphasizes team work, basic engineering calculations, units, design process, hands-on experience, communication skills, report writing and project presentation.

### Sophomore engineering classes

At the sophomore level, the students have studied the first two courses of calculus and basic science courses. And most students already have a good idea about their major. And they study the basic engineering courses including laboratory hands-on experience.

## **Teaching through Learning Activities**

As the studies from Caldwell etc. [1] show that the average attention span of our students is approximately 20 minutes. If we try to give a lot of information to students during a 50-minute class period, students could absorb only a part of materials. During the class, we pass the most important information to the students, and we provide some class time for students' activities. The following are the teaching/learning activities we have for the engineering classes.

### Activities for Motivation

Some of our students have a little commitment for the schoolwork. Sometimes they missed classes or missed assignments, the question of how to motivate students becomes an important issue in an effective teaching/learning process. Part of our activities is Invite in/Visit out. We invite alumni to the school and talk about their successful learning and working experience. We invite professionals to talk about study attitude and skills to succeed the program at the college. We arrange field trips to industrial sites to see the company's facilities, production lines, and learn the real life of engineers. The engineers always give students advice and tips for how to be qualified for the engineers' jobs. The field trips open students' eyes, they are inspired and motivated. Most students are enthusiastic about their future. We expect that these activities can increase the level of student commitment. We maintain a good relation with local industrial companies. Some students have internships with the companies and have been hired by the companies after they completed 4-year degrees.

## Teamwork

The teamwork and communication skills are emphasized and taught through the courses. Each team has 3 or 4 students. We have used several ways to form the teams. One way is to ask students organize their teams, then they would end up with hanging on with their friends. Or the teams are formed based on their similar background. They are in the same section of mathematics classes. It was assumed that the students could help each other in the math work. However, both ways did not work effectively for the design projects. A better way to form the teams is combining students with high GPA and low GPA, and with different high schools and different states background. Students can learn from each other and get better ideas for design project. We ask team to give each member a role and later the role will be rotated. We do not assign the team leaders, since during the learning and design process, the team leaders will automatically recognized by the team members. The leaders are usually those motivated and responsible students. As the leadership demonstration by “Traffic Jam Rules” [2] by Catalyst team at Bucknell University, it shows that how the leadership can be established. The concept of leadership indicates that as a leader, he/she has to voluntarily take more responsibilities, and he/she can handle the conflict well. We gives a partial scheduled class time to the teamwork, the teams have their arrangement for their project, and the team logbooks record all the activities, attendance and progress of the project. The logbooks will be collected by instructor for a reference of the final grade.

## Cooperative Learning

Cooperative learning is an effective way for students to learn the new subjects. Student can be a learner and also can be a teacher. The small-size classes at the college provide an opportunity for students to have class discussion. We create an environment that allows students to ask questions and discuss problems during the class. For those common questions in the homework problems, students are asked to show their methods to solve the problem. The learning process tells us, once you have learned and then you explain or teach to the others, it will reinforce the knowledge you learned. Sometimes students present several ways to solve the problem, then we guide the students to compare the methods, find the best way to solve it. It also makes the students understand that the method can be applied under what conditions. . The problem solving process and class discussion can help students to strengthen their critical thinking ability.

Since students have various background and different experience, some students can grasp the concepts quickly, other’s can not. The quicker learner could help others students to learn the material faster and make the concepts easily and clearly understandable for other students. The nontraditional students have played an important role in the classes. They are hardworking, and are respected by the other students. They commit themselves to the study. Some of them had military experiences; others have family responsibilities. But they have made extraordinary efforts to balance school, home, and work. They are not only the examples but also they are mentors for other students.

We also encourage peer tutoring outside classroom. Students help each other, and at the time of their graduation from the college, they have already built a stronger group and the lasting friendship.

## Laboratory Classes with Computer Software

Computer software has become an important tool for engineering analysis and measurement. The applications of computer engineering software are not given in detail by the lectures. Because the time for the lectures is so limited that can not cover complete applications of any software. Also, some students already have some experience in a particular software, like AutoCAD, C/C++, most students are familiar with Microsoft package.. It is an effective way for students to learn software by practice. We encourage students to learn the software through teamwork, projects, and learn from each other. Student can operate and handle some of the software that is useful for the engineering projects, for example, the students use Excel to calculate the budgets and cost in engineering economics problems, and use PowerPoint to give the presentation.

## Interactive Instruction

To evaluate the effectiveness of teaching and learning, the quizzes and tests can be used for the assessment and outcome. We arrange at least four tests and give quizzes as frequently as we can in a semester. The quiz problems are usually those concepts taught in the last lecture. The advantages for giving enough tests and quizzed are: first, the students have to keep up with the work, and reviews the contents for each class taught frequently. Most students would forget the knowledge they have learned in a longer time period. We think the learning process is a repeating process, just like any sport, students have to practice enough to master the concepts. Second, the instructor has to know how much students have learned. The results from the students' individual work, like tests and quizzes, are usually a good indicator. Then, the instructor knows what the students' weakness is in the subject, and leads the lectures in the right direction. For those key concepts, we want to make sure that the students have learned the material. It seems to take some time from the lecture, but actually it saves time, because the instructor can emphasize the problems that students still have confusion and questions. We encourage students read the book before the lecture, however only few students could do that.

We also have one-to-one advising and tutoring, we closely monitor students' progress. The interactive communication between teacher and students can make teaching and learning effectively.

## Design Project

Engineering design project is a creative activity for students to practice as a team and as an individual engineering designer. We define the outcomes of the student design project based on Bloom's taxonomy [2]. We expect that students will be able to

- Describe basic concepts and steps of engineering design processes;
- Define projects needs, constrains, and certain specifications;
- Use the techniques, skills and modern engineering tools for engineering practice;
- Identify, formulate, and solve engineering problems involved in the projects;
- Design and conduct simple experiments;
- Present the results by written reports and oral presentation;
- Practice teamwork skills.

One of the projects we gave to freshman engineering students is to design a battery-powered car, it is an interdisciplinary project. As a team, students went through entire design process with the knowledge of Mechanical and Electrical engineering. Students enjoyed the project. Half of the teams successfully complete the project. If some team's designed car could not meet the specification, we asked students to find the reason and made a suggestion for modifications. Students learned how to work as a team, and how to work together to achieve the goals. We think we have reached our outcomes for student design project.

## Summary

As Harb etc.[3 ] point out: "The effectiveness of teaching should be evaluated on what is caught and not what is taught". We have focused on what students have learned, how much they have mastered material. The efforts on the effective teaching and learning have made the two-year engineering students are able to successfully complete the 4-year engineering program at the University, some of them are the first generation college students in their families. Recent years, our retention rates are maintained at about 60-70%.

## References

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