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## **AC 2012-4127: LEARNER CENTERED INSTRUCTION IN MECHANICAL ENGINEERING PROGRAM**

### **Mr. Tom Spendlove, Baker College, Flint**

Tom Spendlove teaches engineering and CAD courses at Baker College in Flint, Mich.

### **Dr. Anca L. Sala, Baker College, Flint**

Anca L. Sala is professor and Dean of engineering and computer technology at Baker College of Flint. In addition to her administrative role, she continues to be involved with development of new engineering curriculum, improving teaching and assessment of student learning, assessment of program outcomes and objectives, and ABET accreditation. She is an active member of ASEE, ASME, and OSA, serving in various capacities.

### **Mr. James Riddell, Baker College, Flint**

James A. Riddell is the former Dean of Engineering and Technology at Baker College of Flint, Mich. He currently works at Jazan Economic City Polytechnic in Saudi Arabia. He is a member of ASEE, ASME, SME (Past Chair), and SAE (Past Chair).

# **Learner Centered Instruction in Mechanical Engineering Program**

## **Abstract**

A new initiative at our college has brought into focus improved student learning and retention through the practice of Learner Centered Instruction. This practice includes a wide variety of teaching approaches where students are actively involved in the learning process taking place in the classroom, as opposed to the teacher centric traditional lectures. Engineering faculty have long been using such approaches in many of our courses, for example in courses which include experimental laboratories and projects. This initiative has prompted us to focus more consciously on the effect of teaching on, and the assessment of student learning. This paper will discuss a variety of design projects we are using throughout the curriculum in the Mechanical Engineering program before the Senior Design Project, how they fit with the Learner Centered Instruction initiative, as well as how they support the Program Outcomes and Program Educational Objectives of our ABET accredited program.

Projects from courses taught in the last year or during the current school year will be discussed in this paper.

## **Introduction**

Baker College of Flint is focusing on improved student learning and retention through the practice of Learner Centered Instruction. As faculty and administrators we have attended several training courses over the last few years learning about the methods of Learner Centered Instruction, and current practices in education. This practice includes a wide variety of teaching approaches where students are actively involved in the learning process taking place in the classroom, as opposed to traditional methods of the teacher lecturing in the front of the room and the students taking notes to process later. LCI seems to be a theory of education or a fuzzy goal, just as we would strive to have high quality components in a manufacturing environment we strive to have our students engaged through learning centered instruction. Without setting up specific measurable attainable goals it is difficult to say whether or not we have achieved learning that is centered on the learner.

As Engineering faculty we have long been using such approaches in many of our courses, for example in courses which include experimental laboratories and projects. The act of a student performing an experiment means that the student is engaged in the learning process and is actively participating as a member of the learning team instead of being shown the information and expected to regurgitate it later. The initiative is nevertheless welcome and has prompted us to focus more consciously on the effect of teaching on, and the assessment of student learning.

This paper will discuss a variety of design projects we are using throughout the curriculum in the Mechanical Engineering program that occur before the Senior Design Project. The work of the next academic year is to map how the projects fit with the Learner Centered Instruction initiative, as well as how they support the Program Outcomes and Program Educational Objectives of our ABET accredited program.

## Projects from previous academic years

ME107 Introduction to 3d Modeling - this course teaches students the basics of parametric modeling and sets a foundation to think spatially when tackling a problem. The college has used Pro-Engineer Wildfire 5.0 since the 2009-2010 academic year but regardless of which parametric modeling software is used the students are trained to think geometrically and to intuitively use three dimensions to solve problems that might only be visible in two dimensions. The project for this course is for the students to take an object from their lives and model it on the software. This forces the students to go through the modeling process, starting from a sketch, and identify the main geometric structure of their object and then outline the defining features of the object.

The project assessment:

Paper Sketch – 50 points

10 points for overall look of the sketch

4 points each for identified features

Model – 100 points

20 points for overall look of the model

8 points each for each feature

Report – 50 points

10 points for answering the questions outlined above

4 points each for discussing the features

EE311 Circuit Analysis – this course is taught to mechanical engineering students in their senior year, and includes lecture and experimental laboratory. In addition, in Fall 2011 a hands-on project was introduced to get students to apply what they learned in class to a practical problem. The project was building a Wheatstone bridge to measure uniaxial strain in a loaded beam. Students liked the connection between electric circuits and mechanical measurements. A group of five students worked collaboratively to research this type of measurement, correctly apply the strain gages to the beam under test, build the circuit and perform the measurements. In lieu of a project report, students were asked to create a lab experiment based on this application of the Wheatstone bridge that could be added to the experimental labs for this class in the future. Students followed the model of the experimental labs they performed throughout the quarter to create this new lab. The project was well received. In an end-of-class survey 60% of the students strongly agreed with the statement “The hands-on team project helped me learn the material better.”

ME301 Computer Aided Engineering - in the Fall 2010 term the term project for this course was to analyze a prosthetic arm mechanism. The requirements for the project were that the arm had three distinct pieces that moved independently of each other. This allowed the students without strong modeling skills to build simple cylinders for the upper arm, forearm, and hand while still doing the analysis work. Students were required to perform three analyses from a list of all topics covered in the course. Most students chose to evaluate center of gravity based on the geometry

and material properties of the assembly. This helped to give the students insight into how different materials can change the overall properties of an assembly, and how different grades of steel or aluminum can have different properties. Many other students did motion studies to find the maximum possible distance that the tip of a finger could travel from the end of the forearm, and other students evaluated possible interference conditions between components in the assembly. These different activities all based on the same set of simple requirements are intended to give the students insight into the many different kinds of analysis that can be performed based on a single set of requirements.

ME331 Thermodynamics - After previous ABET evaluations that noted the lack of thermal design in the program a design project was added to Thermodynamics. In 2008 and 2009 using the Cyclepad software developed at Northwestern University the students were required to design and analyze a thermodynamic cycle. As a simulation program Cyclepad gave the student an opportunity to see how the properties interact with each other with immediate feedback. Changing properties of pressure or temperature at one part of the cycle could cause the other parts of the cycle to become impossible, and the software gives the reasons that the new inequality exists. In 2010 a more generic project was given to the students, to evaluate energy that would be required to heat or cool a given space, and then to find a heater or cooler to produce the energy. Students were required to find several options of heaters or coolers that could provide the energy and evaluate the cost per degree and unit of energy that would be used to affect the temperature. Then the students were required to figure out how the current classroom was heated, and required to learn about the heating systems used by the school for our building. This had the overall effect of making the students think about the energy that is used to change temperature and how it can be done easily in theoretical space or new buildings but how difficult it might be in existing space.

ME171 Computing for Engineers - Students are given a list of 10,000 data points related to a set of mating parts, and required to look for the maximum and minimum fits between the parts. Additionally the students are tasked to look for trends of each part over time, and trends for the fit between parts. After this general data mining exercise some basic principles of Monte Carlo simulation and interference fits are discussed, with these principles applied to the project. This project fits well with work that is done in CAD201 Geometric Dimensioning and Tolerancing, and ME495 Engineering Simulation, giving second year engineering students the opportunity to work with CAD students and fourth year engineering students on one project being studied from several different angles.

ME376 Thermal Systems Lab – this course was developed after ABET’s report that the program would benefit from more Thermal Design. The course takes laboratory experiments from Thermodynamics, Fluid Mechanics and Heat Transfer along with a project for the students to design and build a heat exchanger. In Fall of 2010 students developed and built a heat exchanger that was presented at the ASME Student Professional Development Conference held at Grand Valley State University on March 26, 2011.

ME491 Engineering Project Management and ME499 Senior Design Project – these courses are interlocked and intended to give the students a six month long design experience. As the capstone course for our Mechanical Engineering degree these courses being with the product

development process and give the students tools needed to manage the program over the course of its life. Students choose a problem to solve for a design sponsor, research the topic, brainstorm and design a response for the problem, and create a cost / manufacturing / quality plan in the first ten week term. In ME499 the students build a working prototype to validate the concept and do testing and analysis on the working model. These courses are made up of eighty percent activity and twenty percent lecture, with most of the lecture coming in the first ten week course. The best possible outcome of the Senior Design Project course is that the students complete a project that meets all their project goals, but the application of previous learning along with the capstone design is also necessary. The fact that the students are doing projects of smaller magnitude or duration throughout their education should help them to excel in the six month long project course. In Winter and Spring of 2011 the engineering department started a tighter criteria for what can be used for the Senior Design Project topic and that is expected to bring about a better crop of projects for Winter and Spring 2012.

### **Future activities**

Currently as an engineering department we are preparing to map these projects to our Program Outcomes and Program Educational Objectives, along with summarizing the principles of Learning Centered Instruction for the college. Short assessments are also given as one or two question surveys at the end of the course to ask if the students enjoyed the project and to solicit suggestions for future projects.

Our Program Outcomes are as follows: Graduates will demonstrate: a. an ability to apply knowledge of mathematics, science and engineering. b. an ability to design and conduct experiments as well as analyze and interpret data. c. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability. d. an ability to function on multidisciplinary teams. e. an ability to identify, formulate, and solve engineering problems. f. an understanding of professional and ethical responsibility. g. an ability to communicate effectively. h. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context. i. a recognition of the need for and an ability to engage in lifelong learning. j. a knowledge of contemporary issues. k. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice. l. an ability to apply principles of engineering, basic science, and mathematics (including multivariate calculus and differential equations) to model, analyze, design, and realize physical systems, components, or processes. m. an ability to work professionally in both thermal and mechanical systems areas. These outcomes are modeled after ABET's a-k outcomes, with our two additional outcomes added at the bottom.

In general all of the projects discussed above can be applied to most of the program outcomes to some degree. Ideally each of our program outcomes will have one project from a first or second year class and one from a third, fourth or fifth year class that demonstrates we are meeting the outcome. This also fits in well with our learning centered instruction initiative at the college so we can not only show the school what we're doing but show them how it fits into the confines of our accrediting body.

The Program Educational Objectives are to prepare graduates who: 1. demonstrate competence in engineering practice in local and global industry environments, or in related careers in government or academia. 2. exhibit effective communication, team work, and readiness for leadership while acting ethically and professionally. 3. maintain awareness of societal and contemporary issues and fulfill community and society's needs. 4. actively engage in lifelong learning, by completing professional development/training courses and workshops, acquiring engineering certification, or pursuing and completing an advanced degree. We generally measure these objectives three to five years after a student graduates from our program, but still plan to make sure that these objectives are evident in the projects done by the students.

### **Bibliography**

ABET. "Criteria for Accrediting Engineering Programs, 2011 - 2012." *ABET.org*. ABET.org, 2011. Web. 10 Jan 2012. <<http://abet.org/eac-current-criteria/>>.

L.G. Bullard and R.M. Felder, "[A Student-Centered Approach to Teaching Material and Energy Balances. Part 2. Course Delivery and Assessment.](#)" *Chem. Engr. Education*, 41(3), 167-176 (2007). Description of an implementation of the stoichiometry course that made extensive use of active and cooperative methods.

Doyle, Terry. *Learner Centered Teaching: Putting the Research on Learning into Practice*. 1st. Sterling, Virginia: Stylus Publishing, 2011. Print.

R.M. Felder, "[It Goes Without Saying.](#)" *Chem. Engr. Education*, 25(3), 132-133 (Summer 1991). An illustrative engineering lesson utilizing active learning.  
Guerrero, Hector. *Excel Data Analysis: Modeling and Simulation*. 1st. New York: Springer, 2010. Print.

M. Prince, "[Does Active Learning Work? A Review of the Research.](#)" *J. Engr. Education*, 93(3), 223-231 (2004). A paper by Michael Prince reviewing the research evidence for the effectiveness of active learning.

Qualitative Reasoning Group, . "Cyclepad." *Qualitative Reasoning Group*. Northwestern University, n.d. Web. 12 Jan 2012.  
<<http://www.qrg.northwestern.edu/projects/NSF/cyclepad/cyclepad.htm>>.