AC 2011-781: THE IMPACT OF ACTIVITY BASED LEARNING, A NEW INSTRUCTIONAL METHOD, IN AN EXISTING MECHANICAL ENGINEERING CURRICULUM FOR FLUID MECHANICS

Lynn Albers, North Carolina State University

Lynn Albers received her B.S. in Mathematics with a minor in Music from the Massachusetts Institute of Technology in 1992 and her M.S. in Mechanical Engineering with a concentration in Nuclear Engineering at Manhattan College in 1996. After working for Nortel Networks and the North Carolina Solar Center, Lynn matriculated at North Carolina State University where she is a Ph.D. candidate in Mechanical Engineering. Her dissertation spans the Colleges of Engineering and Education and will be the first of its kind at NCSU.

Laura Bottomley, North Carolina State University

Laura Bottomley received a B.S. in Electrical Engineering in 1984 and an M.S. in Electrical Engineering in 1985 from Virginia Tech. She received her Ph.D. in Electrical and Computer Engineering from North Carolina State University in 1992.

Dr. Bottomley worked at AT&T Bell Laboratories as a member of technical staff in Transmission Systems from 1985 to 1987, during which time she worked in ISDN standards, including representing Bell Labs on an ANSI standards committee for physical layer ISDN standards. She received an Exceptional Contribution Award for her work during this time.

After receiving her Ph.D., Dr. Bottomley worked as a faculty member at Duke University and consulted with a number of companies, such as Lockheed Martin, IBM, and Ericsson. In 1997 she became a faculty member at NC State University and became the Director of Women in Engineering and K-12 Outreach. She has taught classes at the university from the freshman level to the graduate level, and outside the university from the kindergarten level to the high school level.

Dr. Bottomley has authored or co-authored 37 technical papers, including papers in such diverse journals as the IEEE Industry Applications Magazine and the Hungarian Journal of Telecommunications. She received the President’s Award for Excellence in Mathematics, Science, and Engineering Mentoring program award in 1999 and individual award in 2007. She was recognized by the IEEE with an EAB Meritorious Achievement Award in Informal Education in 2009 and by the YWCA with an appointment to the Academy of Women for Science and Technology in 2008. Her program received the WEPAN Outstanding Women in Engineering Program Award in 2009. Her work was featured on the National Science Foundation Discoveries web site. She is a member of Sigma Xi, past chair of the K-12 and Precollege Division of the American Society of Engineering Educators and a Senior Member of the IEEE.
Abstract

Replacing lecture time with activity based learning positively affects university students in undergraduate fluid mechanics by reinforcing concepts learned during lecture, visually teaching new concepts and providing an outlet where the students are free to interact more casually with the instructor and their peers. Results of this are higher student achievement, a more thorough understanding of the material and a more positive attitude towards learning. We will show the impact of activity based learning through surveys and observations.

Activity based learning is a new instructional method applied to an existing mechanical engineering curriculum for fluid mechanics. The new instructional method involves students in hands-on activities that are originally designed or modified from existing activities by the graduate instructor, student presentations, instructor demonstrations and projects. Fluid mechanics is one of the more disliked courses in the engineering curriculum due to the difficulty of the material. The goal of the activities, that address the same objectives of the course, is to help the student grasp the concepts and improve the overall learning experience.

Introduction

“Conventions afford us economy of existence, ways of dealing with the day to day rigors of living without re-encountering or reinventing the world every day. So conventions are the source of great comfort, even if this is at the expense of thought.” [1] This has never been more evident than when observing university students. They are so used to routine and feeling that if they complete a checklist and receive a good grade that they have learned. Perhaps they have learned the material but they haven’t learned how to think. From observation, students treat classes as something on a to-do list with the reward being a degree when they have checked off all items on the list. Within the scope of a class, students find great comfort in their to-do list of 10-12 weekly homeworks, 3 tests, maybe a project and then a final exam. All items are treated as part of a to-do list. When homeworks are only worth 10% then they either copy problems from the solution manual or turn in poor work only to wait until the solutions are posted to learn the material. Thus, there is no effort or incentive to read the book, try to solve the problem on their own (which is the point at which great learning occurs) and truly understand concepts. They once again take comfort in conventions, thinking that by understanding how to solve a few types of situations that this is all the knowledge they need. However, this is not sufficient. It is essential to understand concepts and math skills that can be applied to any situation to find a solution. This is particularly true with the study of undergraduate Fluid Mechanics. This course is often taken upon completion of Statics and Dynamics and in tandem with Introductory Thermodynamics. It is a student’s first experience with solving problems where you cannot just look up an equation, use it and get the right
They must apply the conservation laws to develop equations to solve for the flow of the fluid. There is no one, pre-existing equation for each type of problem. In this case, one must reinvent and cannot fall back upon pre-existing conventions.

So this begs the question, “How do we break convention?” The short answer is, “Active learning through hands-on activities.”

Dr. Richard Felder has long been a proponent of active learning, which he defines as, “Active learning is anything course-related that all students in a class session are called upon to do other than simply watching, listening and taking notes.” He does not propose to entirely eliminate the act of lecturing, however highly encourages that active learning be incorporated into the classroom experience. He proposes that teachers engage students in relevant activities involving problem solving that last 30 seconds to a minute. One of the things he suggests that the instructor do is have the students explain a complex concept in terms a high school student could understand. [2] This lends itself well to support the objective of the Lesson Plan project whose underlying goal is to teach the concept by forcing the student to teach the material to someone much younger. Dr. Ron Campbell is a huge proponent of learning by teaching and always encourages students to teach through 5-minute presentations.

This paper describes activity based learning as a new instructional method applied to an existing mechanical engineering curriculum for fluid mechanics. The new instructional method involves students in hands-on activities that are originally designed or modified from existing activities by the graduate instructor, student presentations, instructor demonstrations and projects. Fluid mechanics is one of the more disliked courses in the engineering curriculum due to the difficulty of the material. The goal of the activities, that address the same objectives of the course, is to help the student grasp the concepts and improve the overall learning experience.

There were many aspects of this experiment. This paper will focus on the students’ perceptions of how effective the activities were in their learning. The students were given a survey at the end of the course asking: “How helpful were the activities in learning fluid mechanics?”, “How helpful were the activities in learning math?”, “How challenging were the activities?” and “How well did you enjoy the activities? Two classes of students were surveyed; one in the fall 2009 (N=33) semester and the other in the spring 2010 (N=23) semester.

**Experiment**

The inspiration for the experiment came from two sources. The first was from the desire to make Fluid Mechanics a course that students would enjoy. The challenge was how to accomplish this. The solution came from working with North Carolina State University’s GE Foundation and National Science Foundation funded GK-12 Outreach Program, RAMP-UP, where hands-on activities were used to teach math and engineering to children in grades 3-5. Upon observing the students’ success in grasping concepts, it was decided to try a similar approach with university students. Thus was born the idea of
using activity-based learning in a fluid mechanics course. However, the activity-based learning would take a slightly different form than that proposed by Dr. Felder. Instead of problems to solve, the students would build three-dimensional objects that would demonstrate the concept being taught and then they would learn the math corresponding to it. In addition to in-class activities, there were out-of-class projects designed to help visualize the concepts. These projects were titled Flow Visualization and Lesson Plan.

Six, in-class activities were performed throughout the semester coinciding with the relevant lecture material in class. Two out-of-class projects were assigned with due dates corresponding to relevant lecture material. The six in-class activities were titled, *Rainbow Layer Cake* ©, *Foil Boat, Float, Float* [3], *Sink or Swim* (Bowling Balls and Soda Cans in Water), *Marshmallow Madness* (Control Volume Analysis) ©, *Twist and Turn* (Fluid Flow) ©, and *Construction Function* (Pipe Flow) ©. Students were given approximately 30-40 minutes to perform each activity. They were encouraged to work in groups of 2 or 3.

*Foil Boat, Float, Float* which is an original RAMP-UP activity designed for middle school students. However, it can easily be adjusted to teach elementary school students as well as college level students the concepts of geometry, weight and buoyancy. During this activity, students are given an equal size piece of aluminum foil and are given the freedom to design the shape of the boat and test it in a tub of water. Glass beads are used as weight and the goal is to design a boat that will hold as many beads as possible. Students of all ages enjoy this activity because they like to mold the aluminum foil sheet into many different shapes in order to hold the greatest number of glass beads. Surprisingly, the record for holding the most glass beads is held by a second grader. She designed a boat that held 175 beads.

**Survey Data**

The students were given a survey on the last day of class to determine their perception of the activities. They were asked to rank how helpful they thought the activities were in learning Fluid Mechanics and Math using a Likert scale of 1 = very unhelpful, 2 = unhelpful, 3 = neutral, 4 = helpful, 5 = very helpful. The number of responses per level of the Likert scale are shown in Figures 1 and 2 for the Fall 2009 class and Figures 3 and 4 for the Spring 2010 class. Note that the activity, *Rainbow Layer Cake* ©, an original idea, wasn’t created until January of 2010 and therefore there is no survey data to record from the Fall 2009 class.
The students were also asked to rank the perceived level of difficulty of each activity using a Likert scale of 1 = very difficult, 2 = difficult, 3 = neutral, 4 = easy, 5 = very easy. The student responses are depicted in Figure 5 and Figure 6 for the Fall 2009 and Spring 2010 classes respectively.
The students were also asked to rank how well they enjoyed each activity using a Likert scale of 1 = greatly dislike, 2 = dislike, 3 = neutral, 4 = like, 5 = greatly like. The student responses are depicted in Figure 7 and Figure 8 for the Fall 2009 and Spring 2010 classes respectively.
Survey Results

All students surveyed found most of the activities helpful in learning fluid mechanics. The most helpful one was *Construction Function* (Pipe Flow) © with an overall average of 3.79 (N=56). The least helpful was the out of class project, Lesson Plan. This project is either hated or loved but mostly hated. The most frequent feedback is in the form of, “If I wanted to be a teacher, I would have majored in education, not engineering.”
The two activities that proved to be the most helpful in learning math were *Marshmallow Madness* (Control Volume Analysis) © and *Construction Function* (Pipe Flow) © with averages of 3.33 and 3.31 respectively. The out of class project, Flow Visualization, while good for teaching fluid mechanics was not helpful in teaching math with the lowest average of 2.30.

The most challenging activity proved to be *Construction Function* (Pipe Flow) © with a difficulty rating of 2.59.
For the most part, all activities were enjoyable with the most enjoyable one being Flow Visualization with an average of 3.95 and the least enjoyable being Lesson Plan with an average of 2.59.

**Conclusion**

In general, students perceive the activities to be helpful in teaching the basic concepts of fluid mechanics and math. In addition, the activities are enjoyable and help create a more relaxed learning environment in the classroom (from observation).
References:


[3] An original activity from RAMP-UP, a GK-12 Outreach Program at North Carolina State University
# Appendix: Statistical Analysis of Survey Responses

## Independent Samples Test

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## Paired Samples Test

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