EXPERIENCE WITH ACTIVE LEARNING, FREQUENT ASSESSMENT AND STUDENT EVALUATIONS

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Abstract

Active learning is utilized in this work as part of an effort to encourage student-centered instruction. Felder and Brent[1] in their work discussed how the student takes on more of the responsibility for learning and that the teacher becomes more of a coach. Their paper documents that there are many examples[2,3] of how student-centered learning, including active learning techniques, are beneficial to students. These benefits include an increase in motivation to learn, better knowledge retention, increased understanding and better attitudes about the subject matter among the students. Bonwell and Eisen[3] suggest in their paper that "must read, write, discuss, or be engaged in solving problems. Most important, to be actively involved, students must engage in such higher-order thinking tasks as analysis, synthesis, and evaluation." However, Felder and Brent[1] do warn that "while promised benefits are real, they are neither immediate nor automatic". They go on to say that students may not appreciate these new techniques and that "initial instructor awkwardness and student hostility are both common and normal"

In this work, the author introduces several active-learning techniques and uses a minute paper as a tool[4] to assess student learning for each class. Students in a sophomore-level machine elements class, part of the mechanical engineering technology curriculum, are exposed to these techniques to hopefully improve learning but also to judge students' reactions to the newer style. This is accomplished by comparing overall student evaluations that are regularly performed at the end of the class with previous results from the same class offered two other times by the same instructor.

Introduction

After participating in a National Effective Teaching Institute[5] in 2004, the author has begun to incorporate more active learning techniques into all of his classes. A typical student loses interest after about 10 minutes during a lecture. Hence, active learning exercises are designed to engage the students in their own learning process. With this model, the teacher adopts a role closer to that of a coach rather than a lecturer. Students are entrusted with a larger role in their own learning and the learning of their fellow students since many of the exercises involve group and cooperative learning activities.

This study involved a sophomore-level Machine Elements class in an associate degree program in mechanical engineering technology. Several different active learning exercises including students delivering lectures, students presenting problems on the board, and groups of students brain-storming solutions to a design problem, were employed throughout the semester-long class and are mixed with the more traditional lecture approach as a control measure. Some classes also began with a short (20-30 minute) quiz. Occasionally, students were instructed to read a current technical article concerning machine elements and then asked to submit a written summary of the article. As a control element, several classes consisting of straight, traditional lecture were mixed in with the active exercises. Several times during the semester students first completed a short quiz at the beginning of class before the introduction of new material.

In order to gauge the effectiveness of these different approaches, students were asked to write a minute paper at the end of most classes. Students were instructed that the minute papers should consist of 30 – 50 words and be written in complete sentences. The author also prepared minute papers at the end of the sessions and used these papers as a guide for comparing each student paper with a rubric developed by the author. Assessment scores are recorded in a spreadsheet and average and median scores are computed for the class.

Student evaluations are problematic as discussed by Felder.[8,9] He cautions especially regarding evaluations that use the 1-5 scoring approach with vaguely-defined terms representing the numbers. This is the style used by Purdue University. Still, students' overall evaluation scores from this semester are compared with evaluation scores from two previous semesters in an attempt to measure students' perceptions of the active elements. Based on these comparisons, the "common and normal student hostility" mentioned by Felder and Brent[1] was evident.

Instruction Plan Details

Table 1 lists the schedule and instructional plan for the entire semester. The various elements employed are described below.

Lecture
These classes consisted of the traditional lecture approach utilizing transparencies, PowerPoint slides, a document camera and a chalk board. Typically, the scheduled material is presented and then the solutions to one or more homework problems are presented on the chalk board in extensive detail including unit conversions. Except for answering questions from students, there is little interaction between the students and instructor and any student learning is best described as passive.

Lecture plus active learning sessions
During these lecture classes, the instructor incorporated active learning sessions about every 20 minutes. These quick two to three minute breaks consisted of asking the students to work together in groups of two to brainstorm and create a list. This technique is described in more detail by Felder. An example of how this was used relevant to this machine element class was to ask the students to list all the possible ways a gear could fail. After the break, the instructor asked for responses and then wrote those on the board. While this seems simple, it does allow the

students to refocus on the subject and keep them alert. This plan is also represented by lecture plus active element in the schedule shown in Table 1.

Groups solve problems and present on board
Students, working in groups, spend several minutes solving a problem from the text and then each group presents their problem to the class using the chalk board. A similar exercise is used by asking the students to study the solution to a design problem that is presented in the text. These problems are several pages long and include detailed information about computing stresses, relating these stresses to appropriate failure theories and modifying the design to reflect

Table 1. The instructional plan for the Machine Elements course.

SESSION	DATE	TOPIC	READING	TYPE OF INSTRUCTION
1	10-Jan	Mechanical Design	Chapter 1	Lecture
2	12-Jan	Materials	Chapter 2	Lecture + 2 Active Learning Sessions (15, 50)
3	19-Jan	Stress/Deformation	Chapter 3	Quiz 1 + Lecture
4	24-Jan			4 groups each work a different problem, then present solution to class
5	26-Jan	Combined Stresses/Different Loadings	Chapter 4/5	Quiz 2 +Students work problems on board followed by lecture and demonstration
6	31-Jan			Lecture
7	2-Feb			Quiz 3 + Lecture
8	7-Feb			Student groups presenting design examples from book
9	9-Feb	Exam 1 Review		
10	14-Feb	Exam		
11	16-Feb	Columns	Chapter 6	Lecture + column building contest
12	21-Feb	Columns/Belts	Chapter 6/7	Quiz 4 - Evaluations - No minute Paper
13	23-Feb	Belts/Chains	Chapter 9	Lecture
14	28-Feb	Belts/Chains	Chapter 9	Quiz 5 + Student groups presenting design examples from book
15	2-Mar	Gears	Chapter 8	Student Lectures
16	7-Mar	Gears	Chapter 11	Quiz 6 + Students working problems
17	9-Mar	Gears	Chapter 10	Lecture + Active Element to determine failure modes of gears
18	14-Mar	Exam 2		
19	16-Mar	Project Time		
Monday 3/21 – Friday 3/25		**Spring Break**		
20	28-Mar	Keys, Couplings, Seals	11	Lecture
21	30-Mar	Keys, Couplings, Seals	11	Students working in groups to solve problems and present solution to class
22	4-Apr	Shaft Design	12	Students working in groups to solve problems and present solution to class
23	6-Apr	Shaft Design	12	Quiz + Active Element + Lecture

the computations. Again, the students are asked to present the solution to the class, describing in detail the various aspects of the problem.

Student Lectures
Four groups of students were required to prepare a lecture on different sections of one chapter of the text and then present the lecture to the class using transparencies or PowerPoint slides and the chalk board. Student groups were informed a week in advance of the sections that their group was to perform on the board. Most groups prepared slides or transparencies for use during the class.

Column building contest
One chapter of the text investigates column buckling and computes buckling loads for various cross sections of columns. The instructor divided the class into groups, provided construction paper, scissors and tape and required the groups to create a column with each group using a different cross section. After the columns were completed, text books were stacked on each column to determine the most effective cross section.

Minute Papers

At the end of most classes, the students were asked to compose a minute paper of 30 to 50 words describing the main points or themes discussed during the class. At the beginning of the semester, each student was issued a notebook that they used to write all of their minute papers. The notebook was collected after each class. The instructor also wrote a minute paper after each class and used this paper as a guide for assessing the students' work. Also used in that process was the rubric presented in Table 2. The content rubric varies from a value of 5 for showing a full understanding of the main topic to a value of 0 for entirely missing the main topic with four options in between.

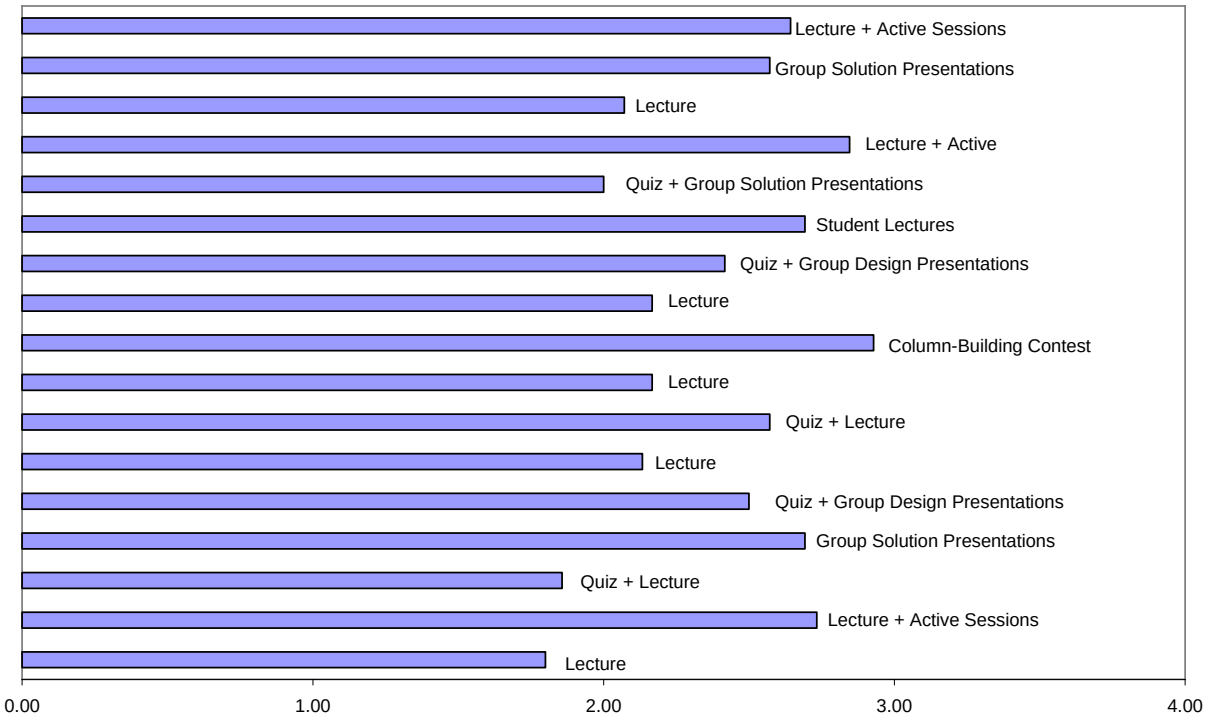
Assessment Results

Figure 1 is a bar graph showing the average content rubric scores for each of the seventeen classes. Each student's minute paper is assessed with the content rubric as compared with the instructor's minute paper and all of the student scores for each of the seventeen classes are averaged to produce the points in the graph. Clearly, the straight lecture classes represent the lowest rubric scores, indicating that students had difficulty determining the main topic of the class. Nearly all of the higher rubric scores, which indicate greater student understanding of the main topic of the class, occurred during classes that contained some active exercise that engaged the students. The highest score occurred after the column-building contest where students were asked to create paper columns with different cross sections and then subjected them to increasing numbers of text books to test the columns. The results certainly support the contention that active

Table 2. The rubric used to assess student minute papers.

CATEGORY	5	4	3	2	1	0
Content	Shows a full understanding of the topic.	Shows a good understanding of the topic.	Shows a good understanding of parts of the topic.	Somewhat coherent description of parts of the main topic.	Bits and pieces of main topic are present but not coherent.	Entirely missed the main topic.

Figure 1. Average Content Rubric Scores from Student Minute Papers



learning exercises in whatever form increase comprehension when compared to the traditional lecture approach. One possible departure from this is a class that begins with a 20-30 minute quiz and then continues to cover new material. Clearly, the students tended to pay less attention after a quiz and this affected learning during the remainder of the class.

Evaluation Comparisons

Table 3 lists the average values of student responses for the same Machine Elements class from 2002, 2003 and 2005. Table 4 shows the ratings scale used for the evaluation questions. These questionnaires are distributed and completed by the students during the last week of the semester and tabulated results are sent to the instructors after the semester. Students were clearly less satisfied with the class in 2005 when the active learning exercises and frequent assessments were

employed. Only one average response reached the value of 4.0 in 2005 while no value in the previous two years fell below 4.0. There could be several reasons for the lower scores. The primary reason is likely too many active exercises and too many assessments that may have simply fatigued the students on both processes. There is a particularly low score regarding the instructor returning graded materials quick enough to benefit the students which is unrelated to this active learning study and certainly may have had a profound effect on students' overall evaluations.

Conclusions

This study incorporated active learning elements into a sophomore-level Mechanical Engineering Technology class, assessed that learning using frequent minute papers and then attempted to gauge the students' reactions to these efforts by comparing end-of-the-semester student evaluations with evaluations from the same class in previous semesters. While the analysis of the data is admittedly limited and not intended to be rigorous, the minute paper assessments clearly showed evidence of increased learning with the active learning elements. Students' reactions, however, to the effort were not particularly positive. Certainly, this effort may qualify as "too much of a good thing" and the students' reactions likely reflect this. It's also likely that the negative reactions could be due to the "student hostility" to new techniques that Felder and Brent discuss in their work[1]. Fewer active learning exercises together with less frequent assessment may produce more positive reactions.

This author has received many comments from students that simply say "work more problems on the board" and "just show us how to use the equations." Either one of these represents a very passive class. It's likely that students have come to expect this and are comfortable with a more passive class that requires little or no interaction from them. Some students will also protest that the teacher acting as a "coach" is not what they paid for. The idea that more learning would occur with a style different from the traditional class may be foreign to students.

Finally, it may be necessary for the instructor to convince students over a period of semesters that they'll learn more with a more active approach. As Felder and Brent[1] state in their work "The key for instructors is to understand how the process works, take some precautionary steps to smooth out the bumps and wait out the inevitable setbacks until the payoffs start emerging." Clearly, persistence with active learning is necessary.

Therefore, the instructor will continue to use active learning exercises in classes, but will do so less frequently. Assessment using minute papers is a valuable tool but clearly was overused in this study. This tool will also be used less often. Clearly, active learning exercises are not for everyone, including teachers and students. A mixture of instructional styles is still recommended for effective teaching and while this mixture will not maximize learning for every individual student it can potentially maximize learning for the class.

References

1. Felder, R.M., & Brent, R.,"Navigating The Bumpy Road To Student-Centered Instruction", *College Teaching*, Vol. 44, No. 2, 1996.

2. Johnson, D.W., Johnson, R.T., & Smith, K.A., *Active Learning: Cooperation In The College Classroom*, Second edition, Interaction Book Company, Edina, MN, 1998.
3. Bonwell, C.C. and Eison, J.A., *Active Learning: Creating Excitement in the Classroom*, ASHE-ERIC Higher Education Report No. 1, George Washington University, Washington, D.C., 1991.
4. Angelo, T.A., & Cross, K.P., *Classroom Assessment Techniques: A Handbook for College Teachers*, Second Edition, Jossey-Bass Publishers, San Francisco, CA, 1993.
5. Brent, R., Felder, R.M., and Stice, J.E., *National Effective Teaching Institute*, Salt Lake City, Utah, June, 2004.
6. Edens, K.M., "Preparing Problem Solvers for the 21st Century through Problem-Based Learning", *College Teaching*, *Vol*. 48, No. 2, 2000.
7. Brent, R., & Felder, R.M., "Writing Assignments – Pathways to Connections, Clarity, Creativity", *College Teaching*, Vol. 40, No. 2, 1992.
8. Felder, R.M., "Random Thoughts . . . What Do They Know, Anyway", *Chemical Engineering Education*, Vol. 26, No. 134, 1992.
9. Felder, R.M., "Random Thoughts . . . What Do They Know, Anyway: II Making Evaluations Effective", *Chemical Engineering Education*, Vol. 27, No. 28, 1993.
10. Felder, R.M., "Random Thoughts . . . Any Questions?", *Chemical Engineering Education*, Vol. 28, No. 3, 1994.

Table 3. A Comparison of Student Evaluation Responses for Selected Questions

Evaluation Question	2002	2003	2005
I understand what is expected of me in this course.	4.8	4.3	3.7
My instructor makes good use of example and	4.8	4.1	3.6
My instructor helps me apply theory to solve problems.	4.2	4.1	3.6
My instructor displays a clear understanding of course	4.3	4.1	3.8
My instructor seems well-prepared for class.	4.8	4.3	3.7
My instructor returns papers quickly enough to benefit	4.8	4.3	2.6
Exams accurately assess what I have learned in this	4.3	4.3	3.6
Exams stress important points of the lectures/text.	4.3	4.3	3.4
Grades are an accurate assessment of my knowledge in	4.4	4.0	3.7
My instructor displays enthusiasm when teaching.	4.3	4.2	3.8
Overall, I would rate this course as:	4.3	4.0	3.8
Overall, I would rate this instructor as:	4.6	4.7	4.0

Table 4. Possible Student Responses for Class Evaluations

Evaluation Response Options	Numerical Values
Strongly Agree	5
Agree	4
Undecided	3
Disagree	2
Strongly Disagree	1