A Student-led Approach to Teaching Advanced Biomechanics

***Renee D. Rogge, Ph.D.*[1]**

Abstract

Advanced Biomechanics is offered as a 3 credit hour technical elective for undergraduates in Biomedical Engineering at Mercer University. The course had been taught previously by the same instructor using a traditional lecture format. The instructor experimented with a new approach to maximize student critical thinking and oral communication skills. The students submitted special topics in the biomechanics field that were of interest to them. The instructor paired the students up on topics (using the submitted topics as a guide) and organized the 'flow' of the course. Each pair of students was given the task of preparing a brief 20-30 minute lecture on the topic of the day. The students' lectures were reviewed by the instructor prior to the class meeting to offer comments and suggestions on the intended topic coverage. In addition to preparing lecture material, each of the two students was responsible for selecting a relevant peer-reviewed journal article and distributing it for the class to read prior to the class meeting. Each student took responsibility for leading the class in a discussion and critique of their selected article.

This paper will discuss the course objectives, the rationale for the instructional technique, and details regarding course management, including grading, peer reviews, exams, projects, and homework. Both positive and negative aspects of this experience, for both the student and the instructor, will be discussed. Areas for improvement and ways to adapt the course for smaller or larger enrollments will be presented.

Introduction

The introductory biomechanics class in biomedical engineering at Mercer University covers traditional topics such as joint mechanics, statics and dynamics as applied to the human body, mechanical properties of biological tissues, gait analysis, fracture mechanics, etc. Following this required introductory course, the students have the opportunity to take a technical elective in advanced biomechanics. In the two previous offerings of this advanced course, the course covered more complicated topics and provided in-depth exposure to research topics and techniques. Within this course the students completed a written journal article critique [Barnett, 1], an independent research project, and several group discussion activities. It was observed during each offering of advanced biomechanics that the student interactions were much more vivid and energetic during the discussion phases of the course. It was also noted that the students' critical thinking skills were maximized during these discussions, as well as their oral communication skills.

Based on these observations, the author decided to change the style of the class from a more traditional lecture-based course, where the instructor "feeds" the information to them, to a more "student-led" discovery class requiring the students to explore topics independently and present their findings to the class. The instructor would still be responsible for ensuring the integrity of the course content, but the lectures would be developed and delivered by student teams (with instructor assistance) and the lecture topic of the day would be concluded with a journal article discussion.

This paper will discuss the details associated with this change in course structure to a student-led approach. In addition, the discussion section will present some of the responses of the students to this type of course and some

[1] Mercer University School of Engineering, Department of Biomedical Engineering, 1400 Coleman Avenue, Macon, GA 31207

faculty responses, as well. Finally, some conclusions and recommendations for others that would like to institute this type of change will be offered.

Methods

Seven students enrolled for advanced biomechanics; all the students were seniors in biomedical engineering who had completed the introductory biomechanics class. This section will discuss the details of developing a student-led course in advanced biomechanics.

Topic Assignments

On the first day of class the instructor described the structure of the course and explained that each student would be responsible for identifying six topics of interest to them in the field of biomechanics. The students listed their top choices for topics and the instructor paired the students up according to topics. Care was taken to avoid having a student present twice in a row. Therefore, at times the "flow" of the course was sacrificed in order to keep the burden down on each of the individual students. In the instances where there was no direct match for student teams, the instructor talked with the students and they matched themselves to the topics left to cover. Some of the topics covered included spine biomechanics, hip biomechanics, sports biomechanics, fractures and external fixation, aging biomechanics, knee biomechanics, osteoporosis, tissue engineering, osteoblast stimulation, ligaments and stress relaxation, finite element analysis, drug delivery systems, rotator cuff biomechanics, bone microstructure, three-dimensional scanning and anthropometry, carpal tunnel syndrome, and osteoarthritis.

Lecture Requirements

Each meeting day, two students were responsible for the class period. One week prior to their lecture day, each of the two students was required to select and distribute a pre-approved peer-reviewed journal article on the topic of the lecture. In most cases, the students brought the article to the instructor for approval and the instructor photocopied the article for each of the students in class following approval of the article content.

The student team was also responsible for delivering an introductory lecture on the topic of the day. In most cases this involved presenting background information that would be helpful when discussing the journal articles, but sometimes involved working sample problems, watching videos, analyzing product brochures, conducting brain-storming activities, completing mini-design problems, etc. Following the 20-25 minute introductory lecture, the student team led a discussion and critique of the journal articles they had selected for review.

Instructor Requirements

The demands on instructor time are typically "behind the scenes". Several days a week there were meetings with the student teams to review, discuss, and approve (or disapprove) the journal articles. The instructor carefully reviewed the articles to make sure the content was appropriate for the level of the students in the course and covered material that enhanced their current biomechanics knowledge. It was also important to probe the student teams for information on the article to make sure that the team understood a majority of the information within the article.

Meetings were also held with each student team prior to their lecture day to discuss their lecture strategy, i.e. what they were covering and how they were presenting the information. The teams were comprised of seniors who were fairly comfortable with formal presentations, but had little experience with a teaching environment. The instructor tried to get them to do as many active learning activities as possible, since most were more comfortable with interactions with their peers. The instructor guided the teams regarding content and references for important information. These meetings were extremely important in order to maintain the integrity of the course and ensure that pertinent information was covered in an appropriate manner.

During the student lectures and journal article discussions, the instructor served as a resource. Care was taken to keep the focus on group discussions and the instructor focused on maintaining the group dynamics. In the event of

controversy or disagreements, the instructor was looked to for insight and additional information on the topic of interest.

Another critical area for the instructor was in providing feedback to the student teams. The instructor provided written and oral feedback to each team in private. During these discussions, strengths and weaknesses for each team member were noted and discussed. The instructor also summarized the class members' responses.

Evaluations and Feedback

Following each lecture, the class members *not* presenting the lecture material were asked to complete a peer evaluation form (Appendix I). Each of the 2 team members was rated on the same form to minimize paper work and time needed to complete the form. Along with rankings from 1 - 10, an area for student comments was provided. The forms were turned into the instructor, who compiled the results. The teams never saw the individual forms.

The student team members completed self-evaluation forms (Appendix II). These forms were discussed individually with the instructor. The instructor also shared written comments from the lecture period. The instructor also evaluated the participation of each of the students not presenting.

Midway through the semester, a progress report was given that summarized the students' performance in the class.

Exams

Two in-class exams were given during the semester. The exams covered information presented by the student teams as well as the content of the journal articles. The main purpose of the exams was to encourage note taking and careful reading of the journal articles.

Project

A project was assigned that required the students to identify an area of biomechanics that was of particular interest to them. Within this field they found two different, yet related articles and wrote mini-reviews of these papers. After evaluating each paper, the students were posed with the task of writing a mini-grant proposal to continue work in this field of biomechanics.

Discussion

There are many positive attributes of a course that is student-led. One of the most obvious benefits is the improved communication skills of the students. The quality of the student lectures improved dramatically over the course of the semester. The instructor also noticed that by the end of the semester the amount of planning time required for each lecture was much less than early in the semester. The students became skilled at organizing the lectures and presenting the information in a clear and concise manner.

The students' abilities to critique a journal article were also enhanced. At the beginning of the semester, the students seemed unable, or unwilling, to criticize a journal article. The feeling of the students was that the printed word had to be true. Through our discussions, the students were more able to discuss assumptions and understand that not all research is perfect. The exposure to research techniques also proved to be a big benefit to these undergraduates with a lacking in practical research experience.

The students developed skills that will benefit them in the future, particularly an understanding of the requirement for life-long learning. Several weeks into the semester, one of the students made the comment that it seems like missing one month of journal articles could put you behind in what is considered cutting edge in biomechanics research. This may be a little bit overstated, but I think it is a testament to that student's realization that life-long learning is required in this, and other, fields.

Student satisfaction with this course was very high. The average rating for the course evaluation on a scale of 1 (poor) to 4 (excellent) was 3.62. One student stated that "this class definitely fostered group learning…I by far learned more in this class than many of my other classes." The instructor attributed this to the style of the class. Since the students really taught themselves, and each other, everything in the class. This is supported by another statement that "This was a very interesting class and a nice break from the usual style of engineering courses." As seniors, the students were more prepared to handle the challenges presented by this class.

This class was very demanding on student time. The students were very dedicated and willing to put in the time to learn the information well enough to teach it. Several students commented that it was difficult to learn something well enough to teach it to other people. The instructor demand was about the same as it was in previous semesters, but the instructor must be flexible and meet with the teams when their schedules are free. Demand on instructor time increased when the topic of interest was outside the instructor's areas of expertise.

Conclusions and Recommendations

In future offerings some modifications will be made depending on course enrollment. The method described previously is suitable for class enrollments of approximately ten students. If fewer students are enrolled, it may be advantageous for the instructor to relieve some of the burden by presenting an occasional lecture throughout the semester. These lectures can focus on research topics of interest to the instructor. Another approach would be to have one day of a Tuesday-Thursday class be a traditional classroom lecture and the following day be a journal article discussion section related to the lecture topic. If more than ten students enroll, the team approach may be abandoned. However, this will increase the burden on each student and also increase the stress level of the individual students. It must be remembered that this is a totally knew experience for the undergraduate student and it is a skill that can only be improved through practice and feedback from the instructor and their peers. It is less intimidating to go through this experience with a partner.

The method of student-led instruction was very successful for this senior-level technical elective. Its success, to a small extent, was dependent on student initiative. The students in this class were very focused on their education since a majority were applying for admission to graduate school. They felt that this class was useful in preparing them for the next phase of their academic lives. It did "feel" more like a graduate school class to the instructor, where the burden was placed on the students and the instructor was more of a guide than a fountain of knowledge. It was a rewarding experience to both the students and the instructor.

References

1. Barnett, Sheila and Rogge, Renee (2002) "Journal Article Critiques: A Complement to Upper-Level Engineering Courses", Proceedings of the 2002 ASEE Southeastern Section Conference, Gainesville, FL.

Appendix I -- Peer Evaluation Forms

Presenter #1: _____ Your name: _____

Presenter #2: _____

Date: _____ Topic: _____

Evaluate the presentation on a scale of 1-10, with 1 being the lowest and 10 the highest.

	POINTS #1 / #2	**COMMENTS**
1. Arrived on time	__/__	_____
2. Prepared with ideas and information	__/__	_____
3. Effective content	__/__	_____
4. Good organization	__/__	_____
5. Clear presentation	__/__	_____
6. Involved all or most of the class members	__/__	_____
7. Kept discussion going	__/__	_____
8. Answers to questions	__/__	_____
9. Effective article summary	__/__	_____
10. Eye contact	__/__	_____
11. Confidence/control	__/__	_____
12. Clarity	__/__	_____
13. Listened to and sought out others' ideas	__/__	_____

General Comments:

Do you have any unanswered questions?

Appendix II -- Self Evaluation Forms

Self-Evaluation Form: Student-led Discussion

Name: _____

Date: _____

Topic: _____

What I did well:

Areas needing improvement:

Points I deserve (out of 100): _____

Why?

Instructor's Evaluation:

Renee D. Rogge, Ph.D.

Dr. Renee Rogge is an Assistant Professor of Biomedical Engineering in the Department of Biomedical and Environmental Engineering at Mercer University in Macon, Georgia. She is the primary faculty advisor for the Mercer chapter of the Society of Women Engineers. She is a co-PI on an engineering education grant totally more than $300,000.

.