

Case Study 3: Integrated Statics and Dynamics (ME 201)

Sherrill Biggers (Mechanical Engineering)

Space and Equipment Requirements for SCALE-UP Classes: The physical layout and resources available for student learning are very important in effective delivery in the SCALE-UP mode. Our class takes advantage of a 1700 square foot classroom space that was created and equipped specifically for instruction and learning in the SCALE-UP mode. The space includes eight large round tables that can seat up to nine students each, with power and wired-internet to facilitate laptop use. However, wireless connections are used by most students. The instructor space includes a Symposium linked to dual projectors using two opposing walls. Students comment that even in the large class, the projected images are easy to read. White boards for instructor and student use occupy the other two walls. Students seem to enjoy being able to easily interact with each other and develop into colleagues as the semester progresses. The tables are well spaced in the room to allow easy access to any student by the instructor and learning assistants. The room is also used for other SCALE-UP classes: Statics, taught by Dr. Schiff in Civil Engineering, and also for non-engineering classes such as Management.

Course Description and Time Allocation: ME 201, an integrated dynamics and statics course, is required of all Mechanical Engineering majors. It is a five credit-hour course that replaces the traditional pair of Statics and Dynamics courses (3 credits each). The first time ME 201 was taught in Fall 2006, it met five days a week as a “3,4” course (three “lecture” periods and four “lab” periods). Three meetings were standard length 50-minute classes and two were extended 100-minute classes, though neither meeting could be classified as lecture or lab. Observations in that initial semester indicated that the longer classes were far more effective than the shorter ones. Therefore, in the following spring semester, the course was taught three days a week with 115 minute classes. This number was arrived at naturally as it is two standard 50 minute classes plus the 15 minutes between classes. This proved to be a superior approach. Those teaching the course again this current fall agree that this is a much better use of time.

In the summer of 2007, one section of the course was taught in twenty five 4 hrs and 45 minute sessions. Students had a 15 minute lunch break and they all brought their food and ate at the tables. This proved to be an outstanding approach; the added efficiency of the extra long classes often allowed class to be end early, and their extended contact allowed effective discussions and camaraderie among the students. The extended period SCALE-UP classes seemed to develop into a workshop atmosphere that was conducive to learning.

Planning a SCALE-UP Lesson: SCALE-UP class meetings are a combination of lecture, discussion, learning activities, and assessment. The balance is typically 30% lecture, 60% discussion/activities, and 10% assessment, though this can vary greatly depending on the content, activities, and instructor.

Lecture: Our lectures place the day’s class into context relative to past and future classes, to provide only highlights of key points, and to provide additional motivational information that might supplement or clarify their pre-class reading. This presumes that the students have actually done the pre-class reading! Some accounting for this critical step in their learning is needed, and is addressed below under assessment. The content of standard statics and dynamics courses has been completely revised for ME 201 to present an integrated sequence of dynamics and statics rather than the standard serial approach of statics followed by dynamics.

Since no text books are available that use this approach, a complete text has been created that serves as the students' main reading material. This textual material was placed on BlackBoard the first year, but now students purchase bound color copies from the bookstore. A lesson learned by the instructors is that if the students only have the text on their laptop, they do not make notations in class and even worse, with their laptops open, many tend to drift away toward email and other personal matters during class. It is impossible for the instructor to tell whether students staring at their laptop are engrossed in the lesson or watching YouTube. Having hard copies of the reading, students are required to keep their laptops closed during most of the class so their attention can remain more on the instructor and the projected images. We supplement the text with the e-book by Bedford and Fowler (Prentice Hall) which is packaged with the primary text. Since lectures are typically only short summaries of important points, the importance of critical reading has been stressed to the students. To assist this thorough approach to reading, study questions are provided that the students can use to assist their reading. Students may choose to enter their response in a written journal.

Lectures are planned with a minimalistic approach, focused on the essential points that students might not get from the reading or in-class activities. Also, the lecture can prepare the students to be efficient in the in-class work. Because I expect students to have read the text, I prefer to project the actual pages from the text during lecture so that students can annotate their pages readily. This also gives them more ownership of their reading material. Other professors prefer to extract material from the text and present it in PowerPoint slides. This has the advantage that it helps keep the lecture on point and on time. Both approaches are valid, though I personally feel the former is preferable. Learning to limit the time spent lecturing is usually a hard but important lesson for instructors new to using SCALE-UP. If students can learn a concept, process, or principle by using it or discovering it, they have a better chance to really learn rather than just absorb.

At a number of times during a lecture, I typically pose a question to the students that they consider and develop an answer in groups. I then call on several groups to present their answers. This has the advantage of encouraging attention, critical thinking, and communication. It can also provide real-time feedback as to whether the students are ready to move on to new material or whether additional discussion is needed. These discussion opportunities are not usually planned in advance but result from observation of student responses during the lecture. Individual student questions are encouraged and are frequent. The lecture is adjusted as needed.

Learning Activities: The in-class learning activities seek to develop skills in problem formulation, problem solution, and reflective evaluation of the solution. They may also involve developing conceptual understanding. Many of the activities have been designed to allow students to discover certain fundamental principles rather than the traditional approach of being told the principles or have them derived by the instructor. Most of the activities are done on paper, though occasionally physical activities are used. These tend to be quite time consuming, but students seem to like them. We place the activities on BlackBoard and expect the students to have printed copies in class. If desired, some or all of these can be collected. After a first semester of collecting these papers, we found that simply observing each student's participation and questioning each student during the activities is just as effective in getting full participation.

The learning activities are done primarily as collaborative efforts although observers work to ensure that each team member is actually contributing to the outcome. Some activities, such as white-board presentations of student in-class work, involve whole tables of 6 to 9 students. Often tables with two or three groups naturally evolve to working as a single team.

We allow this informal grouping according to the personal dynamics of the students at a given table and see this expansion of the group to a larger team as a positive development.

Guiding Activities During Class: During the academic year, instruction is accomplished as a team of one professor, one graduate student, and from one to two undergraduate student assistants. Standard classes have ranged from 50 to 70 students, with 72 being a maximum in the room being used. In the summer, only 10 students were in the class and no teaching assistants were used nor were they needed. We have found that each in-class observer can deal effectively with two tables or a maximum of 16 students. In the current semester, some sections do not have the needed pair of undergraduate assistants and this degrades the quality of the in-class learning experience although even in this case we feel active learning still has major advantages. While students become impatient when waiting for assistance, this often leads to further peer instruction and hard thinking.

The instructor and assistants move among the tables during the in-class activities observing progress. Each is given the solutions to the exercises. We are both proactive and reactive in this process. Encouragement is given to those falling behind through leading questions to get them back on track. Errors observed are questioned and attempts are made to have the student discover and rectify the error. When students ask specific questions, often we ask the whole table to listen to an answer if it is a particularly good question. Sometimes we simply ask a student who has already solved that problem to discuss their approach with the student who asked the question. If students complete the work early, sometimes “what-if” questions are asked of them to extend their thinking. When a good majority of the class has completed the work we bring it to a halt and move on to the next topic, either through lecture or another learning activity.

We are fortunate to be able to have the same undergraduate assistants serve as Supplemental Instructors (SIs) in optional evening sessions. These are held 4 times per week in the SCALE-UP classroom. The SI sessions function as group study/problem solving sessions where the SI addresses students’ questions on homework. The instructor provides the SIs with solutions to the homework problems prior to the session, so the instructor’s approach, including notation, format, procedure, etc, is maintained. However, these solutions are not simply put on the board to be copied. Rather students must grapple with the work while assistance is provided as needed. These sessions are very important to students’ learning. Occasionally the SIs inform the instructor when particular concepts or methods seem to be widely misunderstood. SI sessions are typically packed with students; a full session means that approximately 40% of those taking the class are present. Attendance is optional, and is not recorded.

Assessment: Assessment follows several paths. Three published concept inventory tests are given on the first or second day of class. These include the Statics Concept Inventory which is usually given on-line out of class and the Force Concept Inventory and the Dynamics Concept Inventory that are given during class. Participation is normally over the 95% level. These same tests are administered at the end of the semester to measure improvement in conceptual understanding. Other members of the research team observe class at certain times. Other instructors sometimes attend and offer their suggestions for improvement. Based on these observations, connections are being made between ME 201 and Calculus III, multivariable calculus, and also other courses in the ME curriculum. The students seem to appreciate and even be amazed by seeing such connections.

More traditional assessment involves grading the homework, short quizzes given in class, four or five major tests, and a final exam. Starting in the Spring 2007 semester, the instructors made use of a customized web-based tool created at Clemson called *MessageGrid*, to administer in-class quizzes. This tool enables students to submit short answers to questions through their laptops. This has provided a practical way to record both individual and group answers to in-class questions on out-of-class readings. We begin most classes with a couple of basic questions on the reading for the day or on material covered during the previous class. This has encouraged students to do the readings, though clearly not all students do so. It has reinforced course content and helped all students start class at the same conceptual level, which enhances team interactions. Questions are sometimes asked during class on the material discussed in class. This encourages students to stay alert in class. Having immediate feedback on student understanding of the reading or the lecture, the instructor can adjust the class accordingly in real time.

Results: Students seem to have adapted well to the new instruction mode although there was noticeable resistance when it was first introduced. This resistance seemed to be centered among two types of students. One was a subset of the very best students who perhaps see in-class peer learning as a hindrance to their progress. However, another subset of the very best students seems to be enjoying the approach and can be seen tutoring other students with excitement. A second small group of students who were and remain resistant to the approach includes the weakest students who come to the course with limited math and problem solving skills and would prefer a cookbook approach. Increasing the length of the classes last spring seemed to create a much better learning atmosphere. The extremely long classes from the summer session were even more effective. With the active learning, team-based approach, the disadvantages most instructors commonly attribute to long classes seem to disappear and in fact the longer classes are a great advantage.

Lessons Learned:

- Students must keep their laptops closed during class. Hard copies of the text and learning exercises are required.
- Students appreciate the use of the Symposium in a large classroom as it is easier to view than a traditional white board.
- Long classes are preferable to short ones. This is exactly opposite to standard instructional approaches.
- Students develop friendships by working in groups and seem to have some degree of fun!
- Students can learn by doing with appropriate guidance. Assisting fellow students enhances the learning of the better students.
- Students do not always immediately see the purpose of the learning exercises. The learning outcomes sometimes have to be explicitly pointed out to the students.
- Students have a great sense of accomplishment after completing the course.