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The Compression of Statics: Is there a Difference Between Summer Session and the Academic Year?

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abstract

The Department of Mechanical Engineering at the University of California, Santa Barbara recently instituted a Summer session in which courses normally taught over a ten-week quarter are taught in six weeks. The purpose is to allow students to complete multiple-course sequences during one Summer session. We chose to include Statics, Dynamics, and Strength of Materials in the Summer since they are pivotal courses in our curriculum. Our study targets the Statics course and addresses whether the concentration of material into a six-week session affects students' ability to achieve the desired learning outcomes. We have constructed an assessment program that consists of student focus groups, student surveys, an analysis of the performance and retention of students subsequent to taking Statics, and a standardized quiz administered to students approximately two years after taking the course. In this contribution, we discuss the assessment instruments in detail and our evaluation results to date. We have analyzed data from three ten-week offerings of Statics and three six-week offerings from 2001 to 2003. Our objective is to develop strategies that will minimize any negative, long-term effects of compressing course material and to build confidence in our program as the Summer quarter continues to expand at the University of California.

introduction and background

Prior to the Summer of 2001, the Department of Mechanical Engineering at the University of California, Santa Barbara offered all required classes for the major once per year. If students fell behind, even in one mathematics class, they were required to take a fifth year of classes to complete the degree. Some students took advantage of the Department of Mathematics offerings in the Summer, but not all.

The situation improved during the Summer of 2001, when the Department of Mechanical Engineering offered Statics (ME 14) and Dynamics (ME 16) as a sequence.[1] These two courses were chosen because students who could not complete Statics, and subsequently Dynamics, before the Fall of the junior year would not be able to take the required two-course fluid mechanics sequence that year (offered in the Fall and Winter). Moreover, those same students would not be able to complete a year-long thermosciences sequence in the junior year. Thus, the inability of students to complete the Statics/Dynamics sequence by Spring of the sophomore year would condemn them to a full fifth year to complete the Mechanical Engineering degree. Given the importance of completing Statics and Dynamics before the Fall quarter of the junior year, these courses were chosen for the Summer session of 2001.

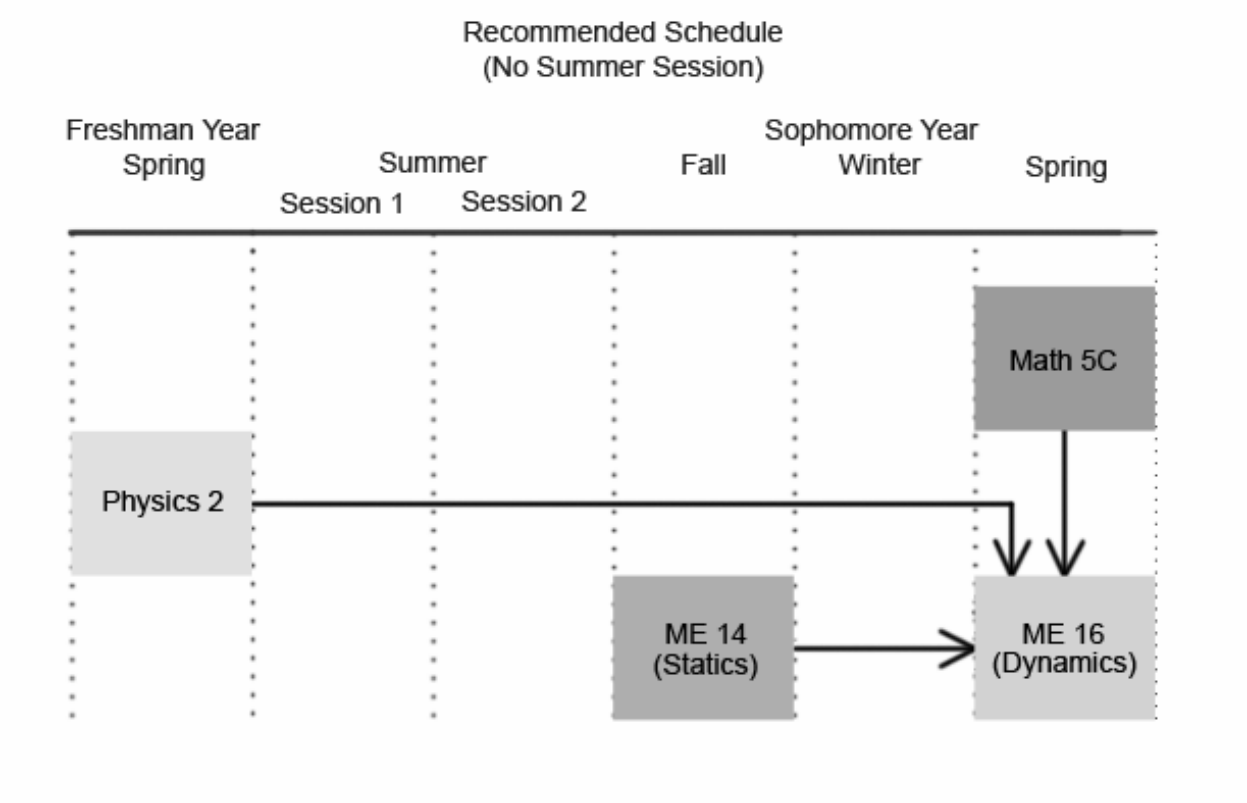
The prerequisites for Dynamics are Statics (ME 14), Physics 2 (covering rotational dynamics, statics, gravitation, periodic motion, fluid mechanics, and thermodynamics), and concurrent enrollment in Mathematics 5C, a sophomore-level calculus course (covering differential equations and Fourier series). Physics 2 is usually taken during Spring of the freshman year. A Mechanical Engineering student who is unable to take Physics 2 during the freshman year has three more opportunities to take it before the second Summer session of the sophomore year: the first session of freshman Summer, the Spring of the sophomore year, and the first session of the sophomore Summer. Statics is offered in the first session of the Summer, while Mathematics 5C is offered in both sessions of the Summer. Typically it is the mathematics prerequisite which prevents students from taking either ME 14 or ME 16 when they are scheduled during the academic year. A flow chart on the next page illustrates the overall sequencing.

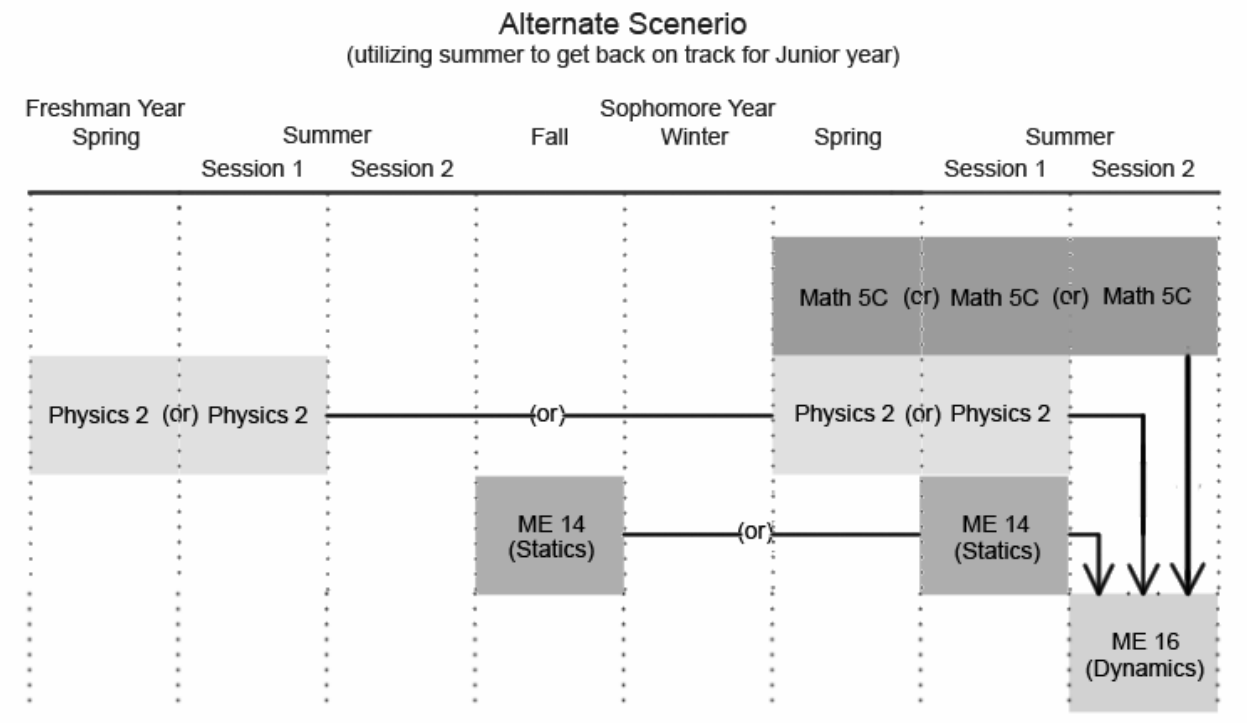
As the Department of Mechanical and Environmental Engineering started the planning for the Summer of 2001, several concerns arose: (i) would we be able to convince faculty to teach in the Summer; (ii) would students take the courses; and (iii) would the fact that course material is concentrated into fewer weeks affect how well students mastered the material? The Summer session of 2001 answered the first two of these questions in the affirmative. During the Summer of 2001 and 2002, both Statics and Dynamics attracted about twenty students. In 2003, Statics had an enrollment of thirty, while Dynamics dropped to approximately 15 students.[2] These enrollment figures modestly exceed the minimum class size for which the university will offer a course. Due to the success of these Summer offerings, several extra "pivotal," or progress-limiting, courses were phased in during the Summers of 2002 and 2003, including Strength of Materials, Electrical Circuits, and several upper division electives.

The only question remaining to be answered from the original three is the third one: i.e., does the concentration of material into a six-week session affect students' ability to achieve the learning outcomes? This question forms the motivation for this study. We have implemented and analyzed several assessment instruments geared to measure our students' level of achievement in one class. We limited the study to Statics (ME 14) due to the consistently high level of enrollment during the Summers of 2001 through 2003, as well as the fact that one of the

[1] The Summer session at UCSB is structured in such a way that two six-week sessions are offered (as opposed to one ten-week "quarter" during the academic year). Classes meet four or five times per week in an attempt to keep the total contact hours at a similar level as in a ten-week quarter.

[2] The drop in Dynamics is attributed to the fact that it was restricted to Mechanical Engineering majors only during the 2002-03 academic year, while the successful completion of Statics was required of all students attempting to change into the Mechanical Engineering major.





co-authors (GEB) serves as one of the Statics instructors, therefore alleviating some of the logistical and administrative burdens.

In parallel with this study, the Department of Mechanical Engineering was preparing for an upcoming ABET accreditation visit and had determined "learning outcomes" for all undergraduate courses in the program. The learning outcomes (not expected to be dissimilar for Statics courses at other universities) for ME 14 are the following:

1. An ability to distinguish between quantities that are described as a scalar vs. quantities that are described as a vector, and the ability to mathematically manipulate vector quantities.

2. An ability to draw free body diagrams - whether for a complete structure or for a portion of a structure.

3. An ability to apply Newton's Law for structures in equilibrium.

4. An ability to identify, formulate, and solve general engineering problems, especially in terms of the forces acting on particles and rigid bodies in rest or in steady motion.

5. An ability to analyze the internal and external forces in frames and trusses.

6. An ability to analyze internal and external forces in beams.

7. An ability to recognize and model the effects of friction.

Our study used several assessment instruments to measure how well the students learned and retained the outcomes associated with Statics. We focused not only on the six-week (Summer) version of Statics, but also the ten-week version offering in the Fall quarter. The purpose, of course, was to examine how well the outcomes are achieved in the two settings and whether there is any difference in the level of achievement of these outcomes due to the different number of weeks over which the material is covered. The centerpiece of our study was a quiz that was administered in December, 2003 and January, 2004 to students who had taken the various versions of Statics over the previous three calendar years. Other instruments included student surveys (interviews as well as written), student focus groups, and an analysis of the subsequent academic progress of students who took Statics. Each of these are discussed in this contribution.

The largest impediment in this study was the fact that over the three-year period under review, one instructor was assigned to teach Statics in the Fall, while a different instructor was assigned to teach Statics in the Summer. Our analysis is designed with this handicap in mind.

survey data

In the Fall of 2002 and the Summer of 2003, Statics students were surveyed on several issues, including their preparation, their major, and, in the case of the Summer students, why they were taking the Summer version and if they perceived any shortcomings to the six-week format. In Fall, 2002, there were 70 respondents. Of these, 87% indicated that they were Mechanical

Engineering majors. The remainder, 13%, indicated that they were attempting to change into the Mechanical Engineering major (from some other engineering or non-engineering major). In Summer, 2003, there were 25 respondents. Only 44% of them were Mechanical Engineering majors, while the balance -- 56% -- endeavored to join the major in the near future. Of the Mechanical Engineering majors, the stated reasons for taking the Summer version were varied. Some wanted to work ahead in the major; some had previously taken Statics but wanted to earn a better grade, and some were supposed to have taken Statics during an earlier quarter and wanted to get back on track with their peers. Obviously, when comparing the performance of those taking Statics in the Fall versus the Summer, one must bear in mind that the makeup of the student groups differs in these respects.

About half way through the Statics course in Summer, 2003, the students were asked about the effectiveness of the six-week versus a ten-week format. Although they had not taken Statics on the 10-week format, they were asked to make this comparison by projecting their experience with Statics onto their past experience with other traditional, ten-week technical courses. An overwhelming majority of students indicated they preferred the six-week format. The reason given for this was that the intensity remains high and the focus remains consistent. In addition, none of the students felt that their ability to apply the concepts in the long term would suffer due to the compressed format.

subsequent progress of students

The number of students in each section of Statics who *left* the Mechanical Engineering major subsequent to taking Statics, as well as the number of students who *entered* the major subsequent to taking Statics, are shown in Table I. As a percentage basis, roughly 15% of students who took Statics in Summer or Fall, 2001 eventually left the major. For those students taking Statics in Summer or Fall, 2002, approximately 5% left the major. Naturally, it is too early to draw conclusions from those who took Statics in 2003.

In Table II, subsequent progress is presented in terms of average cumulative grade point average (GPA), calculated in January, 2004, for all students who took Statics from 2001 through 2003. The metric of overall student performance is remarkably stable, with the exception of the group who completed Statics in Summer, 2003, who seem to be doing slightly better as a group.

Table I. Students entering and leaving the Mechanical Engineering major in the years subsequent to taking Statics.

	Enrollment	Changed to M.E. major after Statics	Left M.E. major subsequent to Statics	Percentage of students who left M.E. major
Summer, 2001	22	2	3	14%
Summer, 2002	21	1	1	5%
Summer, 2003	29	2	0	0%
Fall, 2001	86	3	14	16%
Fall, 2002	86	4	4	5%
Fall, 2003	117	0	0	0%

student focus groups

In the Fall, 2002 and the Summer, 2003 classes, a student focus group was conducted. The intent of these groups was to determine from the students what they brought to the course in terms of background, skills and interest; how much time they spent on the course; how well they felt they learned the material and how they learned the material. For the purposes of the focus group, the content of Statics was divided into four main subject areas: (i) forces, couples and moments; (ii) equilibrium conditions in two and three dimensions; (iii) trusses, frames and machines; and (iv) beams and friction. For each area the students were asked to respond to three questions: (A) How well have you learned the material? (B) What was most important in helping you learn it? and (C) How could your learning experience be improved? The intention of this exercise was to examine any effects that the compression of the Summer term might have on learning. However, it became apparent that the teaching style differences between the two instructors affected the students' experiences.

The Fall, 2002 focus group was conducted in one of the discussions sections. The session started with fifteen students, all of whom were Mechanical Engineering majors. All of the students had to take the class for the major and all of them had the prerequisites for the course. None of the students felt that the amount of time that they needed to spend on the class was unreasonable. In addition to a full course load, some of the students were working on an interscholastic team. All of the students felt that they knew the concepts of the course fairly well. They found the teaching assistants and each other as the most useful resource for learning the material.

Table II. Grade data for Statics students and standardized quiz scores. The GPA metric is based on A=4, B=3, etc. The quiz score is based on a maximum of 20.

	Av. grade rec'd in Statics	Av. cum. GPA as of Winter, 2004	Number of students taking quiz, Winter, 2004	Av. Statics grade of quiz-taking sample	Av. cum. GPA of quiz-taking sample as of Winter, 2004	Average Quiz Score (out of 20)
Summer, 2001	3.05	2.84	8	3.14	3.00	**8.5**
Summer, 2002	3.23	2.84	10	3.55	3.01	**9.7**
Summer, 2003	3.41	3.05	14	3.73	3.22	**10.1**
Fall, 2001	2.38	2.86	36	2.92	3.11	**10.4**
Fall, 2002	3.02	2.99	54	3.48	3.23	**8.0**
Fall, 2003	2.21	2.84	16	2.45	3.02	**8.9**

The Summer, 2003 focus group consisted of nine students. Two of the students were trying to change their major to Mechanical Engineering from within the university and two of the students were new transfer students from the local community college. All of the students had the prerequisite courses. Three students took two other classes along with Statics and two students worked at summer jobs. All of the students felt that they had enough time to learn the material and that they had a good handle on the content of the course. Most of the students studied in small groups, and they found that this was very useful. They also found the examples given in class very useful for learning the material. The students had positive feelings about the Summer format. They liked that they had the same class every day, so the material was fresh, and that the course was not drawn out as in the Fall quarter. Most of the students (six) were only taking one course during this six-week session, so they were able to concentrate exclusively on the material.

standardized quiz

By far, the most quantitative instrument we applied in this study was a quiz administered during Fall, 200, and Winter, 2004 to a wide range of students in the Mechanical Engineering major, who had already completed the Statics course. The students ranged from seniors, fifth-year students, and recent alumnae (who had taken Statics as early as Summer or Fall, 2001) to sophomores who had completed Statics as recently as Summer or Fall of 2003. The quiz was administered over 30 minutes, and no books or notes were allowed. It consisted of four questions, designed to assess the majority of the learning outcomes for Statics listed earlier in this article. (Specifically, there was a simple truss problem, a simple beam problem, a two-dimensional equilibrium problem, and an "essay" wherein Newton's Laws had to be explained.) The quizzes were graded by one individual over a short time period, in order to maintain consistency across the various subject groups.

The results of the quiz are shown in the far right column of Table II. At first glance, there is no discernible trend across the various groups. The scores appear to cluster around a weighted average of 9.1. We believe there are several competing effects in play here. First, there would be a tendency to lose the skills acquired in Statics over time; thus one would expect the score to decrease for students who took the course further back in time. This certainly seems to be the trend with the exception of the group who took Statics in Fall, 2001. On the other hand, the skills acquired in Statics are used in subsequent courses in the sophomore, junior, and senior curriculum. For example, structural analysis is taken up in a Strength of Materials course later in the sophomore year, a Finite Element course in the junior year, and Design courses in the senior year. Moreover, free body diagrams and force analysis are an integral component of other required courses, such as Dynamics in the sophomore year and Vibrations in the junior year. In addition, several elective courses use the principles of Statics. Hence, one would expect that the fundamental skills learned in Statics should only be reinforced over time. Indeed, this is a plausible explanation for the better than average performance by students who took Statics in Fall, 2001. The lack of available students who took Statics in Summer, 2001 to take the test (many of them had graduated by the time the quiz was administered) casts some question on that data point.

On balance, we interpret the quiz results from this instrument to indicate that any long term detrimental effect of taking Statics over six weeks is nonexistent or minimal at best.

conclusions

At face value, we conclude that there are little or no negative impacts associated with the compression of Statics from a ten-week session into a six-week session at the University of California, Santa Barbara. We base this conclusion primarily on average cumulative GPA for groups of students who took Statics in the different formats, their performance on a standardized quiz administered at various times subsequent to Statics, the retention rates of students in the Mechanical Engineering major subsequent to taking Statics, and the students' subjective impressions.

The primary difficulty in implementing this study was that Summer and Fall instructors were different. We intend to carry out a follow-up analysis within the next two years in which we can take advantage of the same instructor being scheduled for both Fall and Summer sessions. In addition, we hope to utilize embedded problems on exams that are identical in Fall and Summer, thus affording us the opportunity to compare short-term retention of skills acquired in Statics.

acknowledgements

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Biographies

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GLENN E. BELTZ received his PhD in Engineering Science at Harvard University and has been a Professor of Mechanical Engineering at the University of California, Santa Barbara, for ten years. His teaching and research interests are in ceramic composite design, solid mechanics applied to materials problems, and aeronautics. He has taught Statics ten times since joining UCSB.