TEACHING HUMAN MOVEMENT TO ENGINEERS: EXPERIENCES FROM NINE INSTITUTIONS

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INTRODUCTION

Biomechanics of Movement was a course originally developed by Scott Delp with contributions from Tom Buchanan at Northwestern University over 15 years ago and subsequently brought to Stanford University. The goal of the course was to take an integrative approach to teaching the biomechanics of movement production by incorporating concepts in muscle biology, muscle mechanics, motion capture, dynamics of linkage systems, and the biology of sensory organs. By including elements from each stage of movement production (Figure 1) in a single course, students would be able to understand the fundamentals of musculoskeletal systems and would be able to access the literature in our field of movement biomechanics. Variants of this course have now been taught at several institutions under different titles, including for example Applied Biomechanics, Engineering Mechanics of Human Movement, Introduction to Musculoskeletal Biomechanics, Biomechanics and Simulation of Human Movement, and Motion Biomechanics. While the overall goal of the course has remained similar across the institutions, this is a heterogeneous group of institutions and students, and thus changes to the content and structure have been necessary. We surveyed the course directors from 9 institutions to address the following primary questions: How does the course structure and content depend on institution or class composition? What topics in movement biomechanics are most difficult for students? What teaching methods are most common and most effective? How can we improve this type of course?

METHODS

We developed a 63 question survey to evaluate the similarities and differences among the courses across institutions and the specific changes that have been implemented by individual instructors. The survey included questions in 7 categories: course demographics, lectures, assignments, laboratory assignments, projects, exams, and additional comments. The nine course directors contributing to this abstract were asked to respond to the survey according to the content of their course, and provide additional comments regarding the history of the course at their institution and the changes that they made in response to the needs of their students and university.

RESULTS AND DISCUSSION

The courses were taught at both public and private institutions (5:4), on semester and quarter systems (7:2), and with and without a TA (5:4). While 7 of the courses had more than 50% undergraduate students, 2 courses were heavily graduate students. Course size was larger at institutions on the quarter

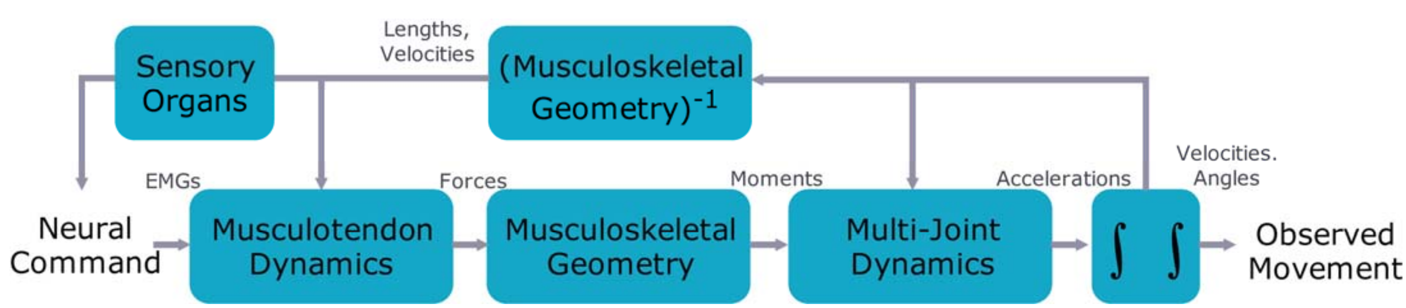

Figure 1. Movement production paradigm. The course includes concepts and mathematical treatments from each of these elements of movement production, and the course syllabus follows the order of the flow chart.

system (p=0.002) and for classes with more than 50% undergraduates (p=0.01). All courses drew students from biomedical and mechanical engineering, with only 2 drawing from kinesiology or exercise science. Prerequisites included dynamics (8/9), statics (8/9); differential equations (6/9), introduction to biomechanics (3/9), and strength of materials (1/9).

Lectures were ranked as more successful at institutions on the quarter system (p=0.03). Student perception of the homeworks (p=0.09) and the success of projects (p=0.01) was ranked lower for largely graduate classes, which tended to be smaller classses. Simulation labs (8/9) and hands-on labs (4/9) were common assignment types, but labs tended to be perceived as more successful at the private universities (p=0.10).

Out of 19 topics specified in the survey (Figure 2), 17 were taught in at least 6 courses. Instructors indicated that solving differential equations, muscle-tendon mechanics, moment arm and muscle architecture interactions, and reference frame transformations were most difficult for students. While the included concepts were similar across institutions, the reading material varied, with 1 course using a text, 6 using readings and 2 requiring both. Readings were largely excerpts of textbooks [1,2,3,4,5], and relevant journal articles.

Instructor comments indicated that alterations were made to the course structure to accommodate course content that was previously taught by another instructor at their university, to incorporate topics and examples relevant to their own research, to increase lecture number when moving to a semester system, to reduce workload for undergraduate students, to accommodate students without strong engineering background, and to engage students without interest in a research career. Comments also indicated that across institutions, students without a background in engineering tended to struggle with the course material.

CONCLUSIONS

The results of our survey suggest that while the conceptual content of the course is largely consistent across institutions, course structure depends on the undergraduate composition of the course and the number of enrolled students. In addition, instructors tend to leverage their research expertise as the foundation for examples and assignment topics. An improvement in reading material for this course - particularly the development of a text reflecting the paradigm of the course - was the most consistently suggested area for future development. Overall, this course provides a solid introduction to movement biomechanics and provides a foundation for students interested in this field to access the types of research performed by members of ASB.

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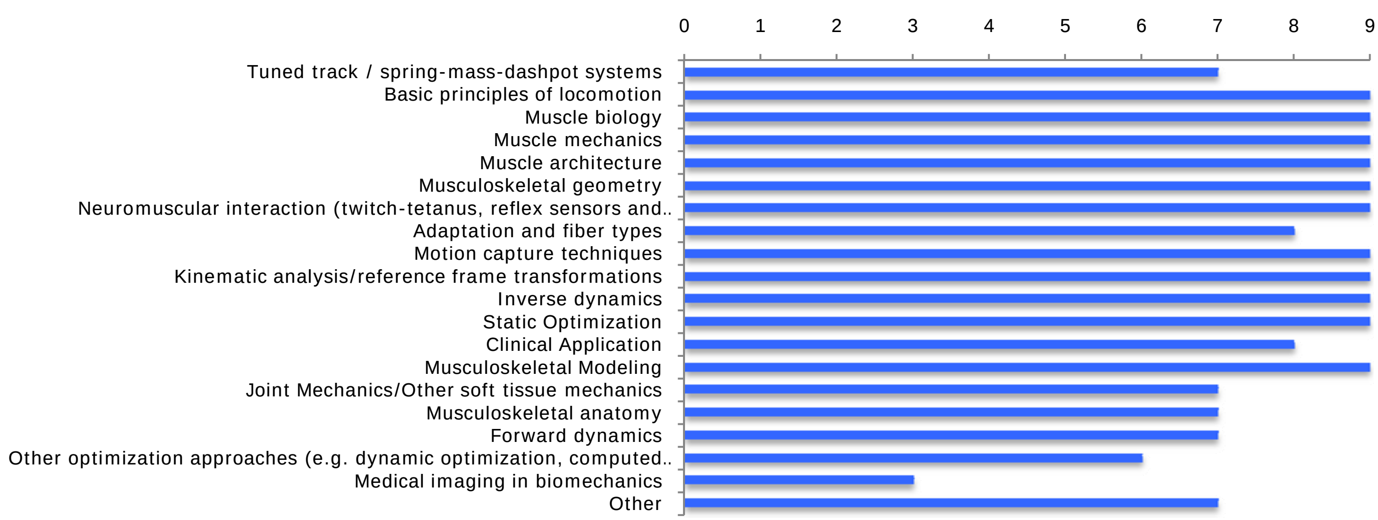

Figure 2. Primary concepts covered in the syllabi of the Movement Biomechanics courses. X-axis indicates number of respondents who include that concept in their class. “Other” examples: mechanobiology, osteoarthritis, EMG, signal processing, muscle and joint power and work.