Clinical Biomechanics Instruction Using Active Learning and Context-Rich Laboratory Experiences

David J. Nuckley

University of Minnesota, Minneapolis, MN, USA
email: dnuckley@umn.edu web: http://www.mbrl.umn.edu

INTRODUCTION

Biomechanics instruction has classically been divided by subset of mechanics (e.g. kinematics, kinetics, mechanics of materials, etc.) or by domain of application (such as orthopaedic injury and treatment, medical device development, tissue engineering, sports, or clinical practice). Different biomechanics classes may have very diverse educational objectives; however they all aim to effectively deliver a broad body of information to students who will apply biomechanics in practice. In clinical biomechanics, for example, the pedagogy of knowledge application through patient assessment is critical for their profession. Thus, for many biomechanics courses, student success is defined by their ability to apply biomechanics principles and knowledge to solve problems.

The typical college classroom involves pedagogy which is passive in nature such as instructor lecture, visual slides, textbook reading, and demonstrations. These strategies usually result in lower material retention rates than active learning strategies such as classroom discussions, laboratory experiences, simulated real-world scenarios, and re-teaching of material by the students [1]. The objective is to describe an experience in teaching clinical biomechanics which engages students in active learning using classroom instant feedback and laboratory context-rich problem solving.

ACTIVE CLASSROOM LEARNING

Active learning is the involvement of the student directly in the learning process wherein they are required to receive information, process it, and act with that information. The learning pyramid (Figure 1) demonstrates the need for active pedagogies in biomechanics to ensure the best retention of the material [1]. An evaluation of Bloom’s Taxonomy of Learning Domains reveals that active learning strategies employ higher order activities like: analysis, hypothesis development, design, synthesis, and evaluation. Not only are these the skills that we hope students develop in a biomechanics class, but they are also associated with much higher concept retention.

Active learning can take many forms in the classroom including, but not limited to small group discussions, in-class problem solving, and physical performance of activities. These pedagogical methods necessitate the integration of the scientific method, biomechanics measurement techniques, biomechanics knowledge base, and data analysis skills. To cement this synthesis by the student, rapid feedback is important. Formative assessment of students is critical at all points within a class session so an instructor may understand the student’s prior knowledge, identify misconceptions / assumptions, develop new ideas, and ensure that the students have met the lesson’s objective. The use of student response systems, like remote clickers, is an excellent way to receive this feedback. While lecture development takes more time as does the discussion of the material, the feedback ensures a higher level of retention. In addition, the students themselves can process this feedback and evaluate their own progress toward meeting the lesson objective. Thus, the active learning biomechanics classroom maintains a dialog between the students and instructor which includes diverse participatory pedagogical methods.
CONTEXT-RICH LAB EXPERIENCES

Nowhere is the active learning environment more evident than in the biomechanics laboratory. In fact, the inclusion of laboratory experiences has been shown to significantly affect student learning in biomechanics classes more than any other pedagogical factor [2]. Laboratory experiences create an environment for students to direct their own examination of biomechanics principles and theories and apply them to real-world problems. The development of laboratory experiences is not easy since there is a constant balance between guiding the students too much and too little. Furthermore, increased technology in biomechanics can make some laboratory experiences cost-prohibitive. This section will provide two examples of context-rich laboratory experiences which spanned the technological spectrum.

In our clinical biomechanics course, students learn simple (goniometer) and complex (optical motion capture) techniques for measuring kinematics. Similarly, they learn EMG and kinetic measurement strategies throughout the course. As a summative assessment of their laboratory experiences, the students perform a task analysis wherein they utilize these measurement techniques to assess a sit-to-stand activity. This laboratory experience involves the students first performing a sit-to-stand and defining all of the variables that they can. Next, they generate hypotheses at each lower extremity joint for each of kinematics, kinetics, and EMG. The next lab class, they test these hypotheses and examine their results (Figure 2).

This task analysis laboratory experience is typically the class favorite because it is an authentic application of their knowledge that is directly linked to their professional success. Furthermore, the scores on this lab experience’s report are highly correlated with final exam scores—revealing the student’s ability to synthesize and use the information they have learned.

Another laboratory experience example involves the clinical analysis of gait. Since most students will experience the need to make biomechanics measurements without a large technology budget, we teach gait from multiple angles. Three modules make up our gait laboratory experience. In one module the students utilize an optical motion capture system (Vicon Inc.) and the plug-in-gait model to assess an individual’s gait. This technology may not be available in all professional environments, so we have another module which utilizes craft paper on the floor to assess the footfalls of a subject at different walking speeds. Finally, in an effort to evaluate patient stability, we utilize a laser pointer fixed on a patient’s PSIS and examine its excursion as the subject walks away from the laser pointer with and without a shoe insole. This experience provides our students with tools of varying degrees of sophistication to challenge and encourage their analysis of biomechanical data.

CONCLUSIONS

Biomechanics instruction sits within the context of many disciplines and includes varying course objectives. A common goal of biomechanics instruction is to empower the student to utilize knowledge, measurement techniques, and analysis algorithms to solve real-world biomechanics problems. Educational theory and best practice involves the use of active learning and context-rich laboratory experiences. These pedagogical methods have also been shown to correlate with the highest retention rates in students. This should serve to motivate more research into educational methods which will provide data to drive enhancements in the instruction of biomechanics.

REFERENCES