Journal of Biomechanical Engineering

Guest Editorial

Special Issue: Annual Education Issue
Biomechanics Education Redux

Introduction

Welcome to the Second Annual Education issue of the *Journal of Biomechanical Engineering*. In our continuing effort to foster and facilitate excellence in biomechanics education, the editors of the journal have created this special issue to highlight innovative teaching practices in bioengineering and biodesign, with a focus on biomechanics. Some of the most exciting approaches for teaching engineering are being created in the relatively young field of bioengineering. Our goal is to both inspire faculty to share their innovative new approaches and to have instructors share their practical descriptions of how they teach bioengineering content effectively. We hope to lower barriers to adoption of evidence-based best practices in teaching and to minimize "reinventing the wheel."

In this issue, we have four invited articles based on education presentations and workshops at the 2016 Summer Biomechanics, Bioengineering, and Biotransport Conference (SB^3C 2016), which describe educational innovations involving clinical simulations, computer modeling, design, and construction of medical devices in a course sequence, and infusing creativity into engineering design. This issue also features nine manuscripts from the student award winners at the conference. All the articles selected for publication are rigorously peer reviewed.

State of Biomechanics Education. In our education issues, we strive for a balance between educational theory and practice. Our belief is that educational efforts in biomechanics should be based on pedagogies backed up by evidence-based methodologies, such as those pioneered by the VaNTH NSF-funded ERC and those currently disseminated by Center for Research, Teaching, and Learning (CIRTL). However, not all the articles need to include controlled studies with multiple cohorts. The dissemination of practical descriptions of attempts (successful and not-so-successful) to incorporate innovative methods can be very useful for instructors contemplating offering a similar course or making changes to current courses. For example, it is difficult to develop and assess open-ended projects and laboratory assignments which provide authentic challenges for the students to demonstrate their knowledge; thus, examples from colleagues in the field are appreciated.

When writing about one's implementation of a new approach for teaching biomechanics, we encourage authors to include a review of literature on best practices of similar methodologies utilized in other fields, e.g., the benefits and pitfalls of incorporating problem-based learning (PBL) [1–3], computational simulations, and primary literature/journal club [4] in technical courses. These descriptions are particularly valuable when coupled with the learning outcomes and student feedback, especially when the instructor starts with the course objectives and then develops assessments and evaluations to map to the learning outcomes and when validated survey instruments are utilized to generate a rich data set.

In addition to methods to better teach core biomechanics knowledge, we also value the inclusion of industrial needs [5] and an innovation/entrepreneurial mindset. Further, we strongly encourage the use of recent research findings published in this journal to educate our students about cutting edge research results and methods, and raw data can be included in JBME manuscripts as supplemental information.

Education-Focused Papers

Our education papers span a wide range of topics from clinical simulations to computational simulations and from medical device creation for actual patients to design creativity through acting.

Anita Singh (Widener University, Chester, PA) describes "A New Approach to Teaching Biomechanics Through Active, Adaptive, and Experiential Learning." This course includes a simulated lab visit in which teams of senior-level undergraduates observe a mannequin "patient" in a clinical setting and identify unmet needs. This novel approach may aid us in overcoming the formidable obstacle of providing clinical immersion experience for ever-growing number of bioengineering undergraduates.

In "Simulations, Imaging, and Modeling: A Unique Theme for an Undergraduate Research Program in Biomechanics," Stephanie M. George and Zachary J. Domire (East Carolina University, Greenville, NC) describe the structure and results of a 3-yr summer research training program for undergraduates with the goal of improving students' knowledge of computational modeling in biomechanics. While they report on a specific REU program, their methods may serve as a template for others developing research experiences for their students in simulation and modeling, topics which continue to grow in importance in the biomedical field.

Alan W. Eberhardt and colleagues provide an excellent description of "A Project Course Sequence in Innovation and Commercialization of Medical Devices" implemented at the University of Alabama at Birmingham, AL, as part of their masters of engineering program. This three-semester sequence focuses on providing hands-on experiences for students that will aid them in product development for hospitals and the medical community at large. The skills the students gain span from CAD/CAM and 3D printing to microelectronics and control systems. They apply their skills in a unified project involving creation of multiple full-scale devices. The students also learn concepts of industrial design including human factors engineering and advanced visualization critical for professional product development.

Ferris M. Pfeiffer and his co-authors at the University of Missouri, Columbia, MO, describe the infusion of creativity and active learning methods into a bioengineering capstone design course in "When Theatre Comes to Engineering Design: Oh How Creative They Can Be." In this well-controlled pilot study, the 1 h/week creativity training developed by a theatre professor led to more than twofold increase in confidence in the "treatment" group. To facilitate adoption of this "curriculum of creativity," the authors include Appendices that provide a survey of confidence and motivation, a creativity course assignment involving journaling, and an example course schedule.

Student Award Winners

Congratulations to our student award winners, nine of whom contributed papers to this issue.

Kerianne E. Steucke, Zaw Win, and their colleagues from Pat Alford's group at the University of Minnesota, Minneapolis, MN, published two papers involving detailed analysis and modeling of vascular smooth muscle cell-generated forces under controlled size, stiffness, and stretch conditions. Steucke et al. contributed "Empirically Determined Vascular Smooth Muscle Cell Mechano-Adaptation Law" and Win et al. contributed "Cellular Micro-Biaxial Stretching to Measure a Single-Cell Strain Energy Density Function."

This issue also contains multiple papers regarding the mechanics of soft fibrous tissues including "Structural and Functional Differences Between Porcine Aorta and Vena Cava," by Jeffrey M. Mattson from the lab of Katherine Zhang at Boston University, Boston, MA, in which they find distinct differences in the biaxial mechanical properties and ECM structure of porcine thoracic aorta and inferior vena cava. Christopher E. Korenczuk from Victor Barocas' lab at the University of Minnesota contributed "Isotropic Failure Criteria Are Not Appropriate for Anisotropic Fibrous Biological Tissues," where the authors demonstrate that, although simplistic, the Tsai–Hill (TH) anisotropic failure criterion performs much better than the isotropic von Mises (VM) failure criterion for uniaxial dogbone-shaped specimens of porcine aorta cut at different angles and stretched to failure. Three students, Ehsan Ban, Sijia Zhang, and Vahhab Zarei, contributed equally (utilizing complementary techniques) to "Collagen Organization in Facet Capsular Ligaments Varies With Spinal Region and With Ligament Deformation." These students were advised by Catalin R. Picu (RPI), Beth A. Winkelstein (University of Pennsylvania, Philadelphia, PA), and Victor H. Barocas, respectively.

Mechanics in rodent models are analyzed in two of the papers. Lauren M. Mangano Drenkard and her co-authors from Boston University in Elise Morgan's lab present "Local Changes to the Distal Femoral Growth Plate Following Injury in Mice." The histology and imaging work presented in the paper demonstrate that therapeutic treatments to reduce bone bridge formation may have different effects local to the site of injury compared to the rest of the growth plate. Out of Spencer Lake's lab at Washington University in St. Louis, Chelsey L. Dunham and her co-authors present "Pronation-Supination Motion Is Altered in a Rat Model of Post-Traumatic Elbow Contracture." This paper investigates range of motion for pronation–supination after injury compared to non-injured elbows—significant in that all the previous investigations have focused on flexion–extension only.

In "Computational Parametric Analysis of the Mechanical Response of Structurally Varying Pacinian Corpuscles," Julia C. Quindlen and co-authors from Victor Barocas' lab describe how the structural variability of these mechanoreceptors will affect sensitivity and response to nuanced tactile variations. These structural changes can occur with disease or aging and give insight into the effects of these processes on our body's tactile response. The effects of aging and disease are also investigated in Fei Fang and Spencer P. Lake's paper, "Multiscale Mechanical Evaluation of Human Supraspinatus Tendon Under Shear Loading After Glycosaminoglycan Reduction." The authors and this paper demonstrate that proteoglycan reduction may not significantly affect tendon mechanics and warrant nuanced investigations between biochemistry and biomechanics.

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