COMSOL Multiphysics® As a Tool for Biomedical Engineering Students to Harness Physical Processes

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Abstract

The field of Biomedical Engineering is expanding at an exponential rate. As we began to unravel clues about our complex biological vessels, we uncovered more questions than answers. Our collective curiosity has led biomedical engineering into a broadening field by study of physiological responses to physical cues; such as electricity, magnetism, thermal effects, mechanical cues, and plasma applications. As we pioneer further into the mysteries of these biophysical cues, it is increasingly important for biomedical engineering students to develop both comprehension and the ability to harness physical cues in application to biological experiments. The COMSOL Multiphysics® software can provide a construct for students new to a discipline to grow a deeper intuition for the processes at play; and design devices specific to their experiments with both, greater precision and less mathematical labor. In addition, many students may run into road blocks during their dissertations and theses due to lack of funding for necessary lab equipment. COMSOL® provides an effective means for students to develop their own low-cost lab tools to overcome certain funding limitations. As a learning tool, COMSOL® can provide students the construct to optimally learn through trial and error of specific problems. For active hands-on learners, the ability to apply mathematical formulations to a spatial model can be extremely effective in developing a correlational understanding whilst nurturing an intuitive comprehension of physical processes. COMSOL® also empowers engineering technology students with the ability to design devices that might otherwise be out of reach with their coursework. In our lab, devices for electrical stimulation of cells, a heating plate, humidity chamber, and a magnetic tweezer apparatus were made at low-cost and modeled with COMSOL®. As well, crude models were generated to qualitatively observe cells' spatial and temporal response to mechanical and electrical cues. While these models are simple in nature they exploit COMSOL®'s potential for bridging disciplines and freeing the mind from rigorous computations to permit creative design. The modules used to generate these models/devices include AC/DC Electromagnetics, Computational Fluid Dynamics, Electromagnetic Heating, Heat Transfer and Phase Change, Structural Mechanics, and Transport Phenomena. Computational software such as COMSOL Multiphysics® possess great potential for propelling innovative design beyond the field-specific experts and provide students the opportunity to culture/apply a multidisciplinary perspective to their work.