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SHARE: Bringing Simulation to the Biomedical Engineering Classroom: the Ansys Academic Healthcare SimLab Application

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Activity Motivation

With the rise of 'In Silico' or computer modeling, simulation tools are increasingly essential in biomedical engineering practice [1] [2] [3] [4]. Unfortunately, the complexity surrounding this can limit adoption in undergraduate curricula. This creates a knowledge gap when new graduates meet industry's computational use and approaches [5] [6] [7].To address these challenges, we have developed the Ansys Academic Healthcare SimLab; a browser based educational simulation tool. Launched in late 2025, the app was designed to support teaching classroom theory alongside real-world tools to help bridge the skills gap in biomedical engineering or medical courses by providing a guided interactive environment for exploring core concepts through simulation applications. By automating key simulation processes (*i.e.* geometry generation), students can focus on interpreting results, implementing and altering simulation workflows, and understanding physical phenomena. Currently, the app contains three modules or "Domains" supporting courses covering Hemodynamic, Bioelectronics and Drug Delivery via the Respiratory System, with more in development. This scaffolded exposure to simulation allows students to gain familiarity with In Silico techniques which improving conceptual understanding.

Learning objectives

The SimLab targets two interconnected learning outcomes.

1. **Students will analyze and evaluate the underlying physics principles governing biomedical applications to develop a deeper conceptual understanding.** By pairing simulation results with analytical solutions, students can visualize how theoretical equations manifest in realistic scenarios, reinforcing lecture content while demonstrating the practical role simulation plays in engineering analysis.
2. **Students will build computational thinking skills by implementing and managing the complete simulation workflow.** Rather than simply running software, students learn *why* each step matters. This emphasis on reasoning, not just procedure, prepares students to approach new simulation challenges with confidence.

Example step-by-step details of implementation in hemodynamics domain

The following outlines how an instructor might implement one of the many activities within the SimLab, specifically the Straight Blood Vessel module in a hemodynamic or fluid dynamics course. This activity has been designed, using feedback from academic beta-testers from over 20 universities, for a single class session (approximately 60–75 minutes). The content can be adapted for use as a lab activity, in-class demonstration, or guided assignment.

Pre-class Activities: Students are expected to review the Theory page within the SimLab's Hemodynamic module, which covers the Hagen-Poiseuille equation and its assumptions (steady, laminar, Newtonian flow in a rigid tube). Currently, the app does not include any pre-simulation calculations for comparison, but instructors are encouraged to add additional problems if deemed necessary to ensure course alignment. Any software required for the module activities (for this lab, Ansys Discovery and Ansys Fluent software) should be installed.

In-class Activity: First, the instructor leads a brief concept overview and introduces the clinical scenario connected to the module (for this module: the effects of plaque buildup on blood flow and vascular health) and the 'In-Silico' workflow being used (Figure 1a).

Students then work through the model's structured exploration, beginning with a baseline simulation of a healthy blood vessel. Plaque is introduced via adjusting the abnormality diameter (Figure 1b) and changes in results such as pressure gradients can be seen. Additional parameters can be modified to control vessel diameter, inlet velocity, and outlet pressure to explore different vascular conditions. Mesh type can be adjusted to reinforce the importance of mesh quality in Computational Fluid Dynamics (CFD) simulations.

Comparisons can be made between simulation outputs and analytical predictions provided in the Theory section, allowing for detailed discussion of factors such as presence of the obstruction and flow regime transitions.

After completing the module, the instructor leads a class discussion highlighting the medical significance of the visualizations; for example, how regions of low wall shear stress correlate with plaque growth, or how elevated pressure gradients indicate hemodynamically significant stenosis.

Potential Assessment Opportunities: There are multiple opportunities for assessment within this activity, including in-built quizzes for each model and external reporting opportunities detailing the comparison between simulation and analytical predictions, mesh convergence studies or students solving a "what-if" scenario, such as comparing two plaque sizes and predicting which would be more clinically concerning based on simulation outputs.

Figure 1: (a) In-Silico Workflow Details & (b) Blood Vessel Abnormality Simulation

Discussion of situational factors affecting implementation by others

Below are a few factors to implementation we have identified through preliminary app feedback and our experience with other educators implementing simulation-related activities in their curriculum, along with app changes we have made to reduce or eliminate them.

Faculty comfort with simulation: To mitigate need for instructor expertise in simulation tools, the SimLab automates technical steps and provides integrated instructional content, allowing faculty to focus on guiding conceptual discussion rather than troubleshooting software or developing supplemental materials from scratch.

Software requirements: The application is designed to run on modest personal computers and runs on Ansy's free student software version, removing hardware and software costs. Minor limitations do exist (*ex:* geometry visualization restrictions in Cardiovascular domain and Ansys Fluent mesh size cap) which are noted for instructor awareness.

Topic coverage: Based on beta-test feedback, additional domain coverage for areas such as biomechanics and biomaterials is being developed.

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