

Engineering Curriculum Development Using Computational Fluid Dynamics

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Computing technology has made a large impact on many areas of engineering education, yet it has been slow to penetrate undergraduate fluid mechanics and heat transfer courses, which have been taught in much the same way for over fifty years. General-purpose computational fluid dynamics (CFD) software has been successfully deployed for both graduate and undergraduate research projects, but the learning curve has made it difficult to integrate these tools with the introductory engineering curriculum. FlowLab (<http://flowlab.fluent.com>), the CFD-based educational software package recently released from Fluent, attempts to fill this void. FlowLab allows students to solve fluid dynamics problems without requiring a long training period. Its mission is broader than just introducing CFD technology to undergraduates; it uses CFD to excite students about fluid dynamics and entice them to learn more about transport phenomena of all kinds.

FlowLab provides students with a "Virtual Fluids Laboratory," in which CFD is used to teach and visually reinforce concepts in fluid flow and heat transfer. Using carefully constructed examples, students are introduced to the effective use of CFD for solving fluid flow problems, and are exposed to software tools that have become increasingly important in industry. FlowLab allows students to get started immediately without having to spend the large time commitment to learn geometry and mesh creation skills required by traditional CFD software. Current academic Fluent users can also create their own FlowLab examples or customize the pre-defined ones.

Buttons for easy navigation through entire CFD process

View CFD results graphically

Input parameters and view CFD results

Customizable exercise notes

Pre-defined X-Y plots, including comparison to experimental data

Flow through a sudden pipe expansion

Parameter	Value	Units
Total Pressure at Inlet	1.8509	Pa
Total Pressure at Outlet	1.42023	Pa
Velocity at Outlet	11.87037	m/s
Total Frictional Force on the Wall	0.314667	N

Position	Static Pressure
0.0	-29.4
0.05	-27.4
1.0	-25.4
2.0	-23.4
3.0	-21.4
4.0	-19.4
5.0	-17.4
6.0	-15.4
7.0	-13.4
8.0	-11.4
9.0	-9.35
10.0	-7.35

The number and range of pre-defined examples is growing. Fluent is working with university professors worldwide to develop a library of FlowLab exercises, which will be available freely through the Internet. Below are the overall educational goals for the FlowLab framework:

- To reinforce the basic concepts of fluid mechanics and heat/mass transfer using computer simulation
- To augment and complement the existing laboratory-based curriculum through the use of computing exercises
- To expand the learning experience with real-world applications of fluid flow and heat/mass transfer
- To expose students to CFD concepts – an increasingly important skill in today's job market

Fluent is working with the CACHE Corporation to explore ways to integrate CFD tools in the chemical engineering curriculum. CACHE's CFD taskforce includes Prof. Jennifer Sinclair Curtis of Purdue University, Prof. Rodney Fox of Iowa State University, and Dr. Richard LaRoche of Fluent.

FlowLab was chosen as the CFD Workshop platform for the 2002 Summer School for Chemical Engineering Faculty, sponsored by the Chemical Engineering Division of the American Society of Engineering Education (ASEE). The purpose of the Summer School is to disseminate innovative and effective teaching methods to a wide spectrum of chemical engineering undergraduate programs. Prof. Jennifer Sinclair Curtis led the CFD Workshop in which chemical engineering faculty explored how FlowLab can be deployed for undergraduate fluid mechanics and heat transfer courses. Her student, Kim Hayden, and Richard LaRoche assisted with this workshop. Fluent continues to work with Prof. Curtis and Ms. Hayden to refine FlowLab exercises and develop instructor materials.

The Division of Undergraduate Education of the National Science Foundation has recently awarded a three-year grant to the University of Iowa, Iowa State University, Cornell University, and Howard University for a collaborative project to integrate simulation technology into undergraduate education. This multi-university project team, headed by Prof. Fred Stern at the University of Iowa, will develop teaching modules for undergraduate fluid mechanics courses and laboratories using CFD, experimental fluid dynamics (EFD), and uncertainty analysis (UA). The project team has partnered with Fluent to use FlowLab for the CFD component of these teaching modules.

The University program at Fluent is eager to collaborate with faculty members to develop new ways to use CFD to enhance the undergraduate engineering curriculum. It is hoped that FlowLab exercises, one component of this effort, will be developed, peer-reviewed, and shared within the academic community. As a result of the programs currently underway, graduating students will be better prepared to enter the workforce in the years to come.