Relating Thermofluids to Life: Enhancing student engagement with project-based learning

Project-based learning enhances student engagement. Thermodynamics and Fluid Mechanics are considered difficult components of Mechanical Engineering curriculum due to the need for numerous abstract concepts and advanced mathematics. In a junior-level Thermo-Fluids course, project-based learning is combined with students' personal and professional interests in order to deepen their engagement with the material. Students propose projects that connect the course material with their interests and hobbies. They work in teams or by themselves. The work on projects begins half-way through the semester. They present demonstrations in a project fair during the allocated exam slot.

We shall present selected student project demonstrations: a model Stirling engine, a hydraulic automaton, an air vortex cannon, a half-hour glass. Students created these prototypes from simple materials such as cardboard boxes, plastic bottles, syringes, soda cans etc. In some cases, students connected knowledge acquired in other courses with the subject matter of this course. In this presentation, students will explain the concept, demonstrate their prototypes, and discuss their process of translating the concept into a working prototype. In addition, they will discuss how their outside-the-class interest encouraged them to dig deeper into the subject matter.

An air vortex cannon releases a dough-nut shaped vortex of swirling air that travels considerable distances and is able to transfer energy to a target. It works on the principle of Bernoulli. An amount of air mass in a container, when exits a small hole, speeds up and experiences lower pressure. The pressure difference between the air at the edges and air at the center causes the air to turn inwards, thus creating a vortex. The students tested the range of travel of this vortex by placing targets in its way. The impact of their prototype canon was felt up to 75 feet. It was heard up to 150 feet.

A half-hour glass was constructed using two fluids of different densities. When the lower density fluid is in the container at the bottom and the higher density fluid is in the container on top, connected through two straws, the lower density fluid rises and the higher density fluid falls. The amount of the liquid is calibrated for one flow cycle to finish in 32 minutes at the rate of 0.625 oz/min. The students were exposed to the working and history of water clocks during class lectures.

A Stirling engine consisting of piston, cylinder, crankshaft, and a heat source was constructed using a soda can, steel-wool, a balloon, a toothpick, a brass bar, and a candle. The students extended the concepts of various thermodynamic cycles discussed in lectures to a Stirling cycle.

A hydraulic crane consisting of two pistons of different diameters was constructed using syringes, plastic tubing, and cardboard boxes. The crane was used to operate an arm that picked an object and lifted it a few centimeters. The crane demonstrates how Pascal’s law can be employed to create automation.

A fluidized bed consisting of sand and air was constructed using a kitty pool, sand, plastic tubing, and compressed air. The students were exposed to the concepts of non-Newtonian fluids in a lecture and a hands-on laboratory exercise.

Coanda effect is the bending of fluid flow to follow the contour of a convex surface. It involves entrainment of fluid creating a region of low pressure. A student performs simple demonstrations using a soda can and candle, and ping pong ball and hair-dryer. Students were exposed to fluid kinematics, dynamics, and flow visualization techniques in lectures and laboratory.

These projects provide students a platform for extending the conceptual knowledge that they acquire in the course to apply it to different contexts. Since these projects emanate from their personal and professional interests, the students are motivated to further explore the course material outside the classroom. This creates conditions for deep learning.