Using Hands-on Thermal-Fluid Projects to Motivate Students

Randall D. Manteufel, A.C. Rogers, and Amir Karimi

Mechanical Engineering
University of Texas at San Antonio

Abstract

Attracting and retaining undergraduate students is a goal of all engineering programs, however each institution operates in different environments and from different pools of students. The majority of student attending the University of Texas at San Antonio (UTSA), are from the South Texas region and a large portion are minority. Because of an open admission policy, many students are admitted who lack a strong educational foundation for college. Students often struggle in classes and there is a relatively low student retention rate in engineering, especially in lower division courses.

In order to improve the retention of students, alternative educational strategies have been evaluated and implemented, including the use of hands-on projects. Such projects have been found to motivate students to be self-learners, appeal to hands-on learners, and improve the overall course performance. Hands-on projects do not replace textbook dominated classes, but augment the class at the expense of increased instructor involvement and/or the use of teaching assistants. The hands-on projects range from exploratory disassembly of equipment such as compressors, engines, pumps, and air-conditioning units, to the open-ended design, fabrication and testing of unique experimental equipment. Introductory classes emphasize familiarization through experimental disassembly, while more senior-level classes emphasize creative design and implementation. A greater emphasis is placed on physical equipment, implementation, and demonstration. Recent projects in three classes: thermodynamics, heat transfer, and thermal-fluids laboratory, are described with an assessment of their impact on student motivation and improved student learning.

Introduction

The use of hands on laboratories is not a new concept in engineering education. However, laboratory projects offer unique education experiences from which students gain hands-on experiences. These experiences prepare them for a variety of positions as test, field and/or manufacturing engineers. In many cases, students seek a mechanical engineering degree because it can be very hands-on.

Different types of students respond differently to the educational opportunities and methods used. Some students learn easier by written, visual, physical, and/or audio input. Some students may struggle in a laboratory class yet excel in a lecture-dominated class. A process, procedure, or apparatus may readily be comprehended from textbook descriptions and illustrations. For some students, they more readily comprehend the device or function if given the opportunity to physically handle, exercise and/or see it in operation.

It has been an observation at UTSA that many sincere students seek to earn a degree in mechanical engineering without a strong math or science preparation at the high school level. Many students enroll in an engineering program years after high school or years after taking a few introductory college courses such as technical physics and calculus. Accommodating these students is a challenge. In most cases, these students must demonstrate an increased ability, desire, and commitment to their education. There is a benefit of such students in a class, because they often are inquisitive and bring their job experiences into the course. Overall, these students are application and hands-on oriented. By appealing to application oriented problems, more of them are motivated to work hard and overcome their lack of a rigorous academic background.

Application

In the thermal-fluid sequence in mechanical engineering at UTSA, we are moving to give students hands-on educational opportunities in three classes: ME 3293 Thermodynamics I, ME 4313 Heat Transfer and Rate Processes, and ME 4802 Thermal-Fluids Laboratory. The implementation of the hands-on approach is discussed further.

Thermodynamics represents a "gateway" class in the ME program although the term is not officially used. Over the years, it has been observed that many students attempt Thermodynamics. If they pass, then the have a very high probability of eventually succeeding in earning a BSME degree. If they fail, they often dropout especially after attempting the class more than one time.

The lectures, homework, and exams continue to be emphasized in thermodynamics. A voluntary hands-on laboratory is introduced to help many of the students. The laboratory varies from semester to semester, with the thrust being the acquisition, disassembly, study, and re-assembly of common equipment. Examples include: window air-conditioner units, refrigerator compressors, small (3 to 5 hp) gasoline lawn-mower engines, and small two-stroke leaf blower type engines. All of these come from real applications that drive home the practical, life-affecting aspects of thermodynamics. Figure 1 shows a student engaged in the tearing down of an automotive AC compressor. The student is asked to describe how the equipment works and trace the flow of the refrigeration from inlet to outlet. Pictures document the activity and the student writes a few sentences describing the activity.

Figure 1. Student Showing Disassembled Automotive AC Compressor.

In the heat transfer course, there is a design project. We have moved to using hands-on projects for the design. As an example, students have laboratory access at UTSA to working equipment such as the cold carbonated beverage dispenser that is designed, manufactured and marketed by Lancer of San Antonio. Figure 2 shows a working model donated to UTSA for educational purposes and especially for the heat transfer class.

Figure 2. Cold Carbonated Beverage Dispenser Showing Ice Bank Tank with Product Lines.

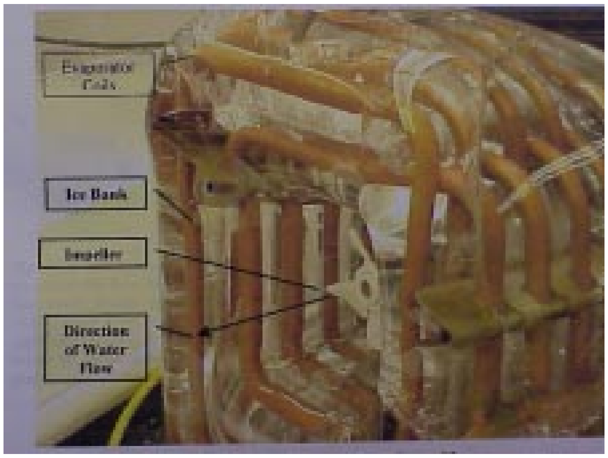

Figure 3. Ice Bank on Evaporator Coils Promptly after Removal from Ice Water Tank.

Figure 4. Assembly to characterize the performance of a computer case fan.

After becoming familiar with how the device works, students are asked to evaluate potential redesigns that are related to real objectives. Examples include: lowering the casual drink temperature, increasing the number of consecutive drinks, decreasing the time for draw-down, and reducing stray heat transfer into the ice bank, Figure 3. Students can collect data from two working dispenser models in order to support their ideas. Last semester, one model was fully equipped and attached to a syrup bag so that they could drink a cold soda while considering ideas. For this class there is not enough time for students to implement and test each design idea, however, all redesigns are based on real working equipment.

Figure 4 illustrates more senior-level hands-on activities such as an experimental set-up that is entirely designed and implemented by a student to measure the characteristic curve of a computer case fan. This was one of about five such hands-on laboratory exercises in a 3 SCH class. Although the experiment is not elaborate, it is unique. No other student had the same assignment. The student selected the equipment and configured the apparatus from those available in the laboratory in order to collect and reduce the data to the appropriate format.

Figures 5 and 6 illustrate a water-cooled camera housing to use in a fire test facility. This was done at the end of a 2 SCH thermal-fluids class in which students already conducted ten standing experiments. It is an original project based on a clients requirements (Southwest Research Institute, San Antonio TX). The camera provides real-time video within a fire facility that tests the flammability of wall materials. The case protects the camera from the high temperature fire and included the circulation of cooling water and continuous introduction of air in the front lens, which keeps soot and particles from blocking the view. The camera was tested in a ten-minute fire test at SwRI and yielded valuable data about the importance of wall seams.

Figure 5. In-furnace video camera housed in water-cooled jacket.

Figure 6. Video camera installing a fire test furnace prior to a test.

Summary and Conclusions

Hands-on laboratory projects in thermal-fluid classes have been used to help motivate students by exposing them to life-affecting applications early in the sequence of courses. The laboratory experiences gradually increase in complexity from:

- disassembly and explanation,
- quantitative evaluation and proposed re-design,
- design, construction, and implementation.

All of the projects are hands-on. In addition to the traditional educational objective of having students exposed to working equipment in laboratory classes, there is an effort to motivate students by introducing hands-on laboratory projects throughout the curriculum. It has been observed that many students have practical work related experience, often at the expense of strong academic backgrounds. Many such students often become more enthusiastic about the course because of these hands-on projects, hence they are more motivated for the rigors of the class because they are exposed to real applications.

RANDALL D. MANTEUFEL
Dr. Manteufel is an Assistant Professor of Mechanical Engineering at the University of Texas at San Antonio. His research interests include engineering education, heat and mass transfer, importance analysis and sampling schemes. Dr. Manteufel is a registered Professional Engineer in Texas.

A.C. ROGERS
Mr. Rogers is an Lecturer in Mechanical Engineering at the University of Texas at San Antonio. He is retired for Southwest Research Institute and has research experience are in applied thermal-fluids, low-gravity mass gauging, and experimental design. Mr. Rogers is a registered engineer in the state of Texas.

AMIR KARIMI
Dr. Karimi currently serves as Professor and Head of the Mechanical Engineering and Biomechanics Department at the University of Texas at San Antonio. His research interests are in metastable thermodynamics, phase change heat transfer, design of energy recovery systems. Dr. Karimi is a registered engineer in the state of Texas.