EUE Proposal
FY2019

Project ID#

19-16

Project Title

Integrating Studio Teaching into an Engineering Thermodynamics Course

Project Director	ID Number	Telephone	Email
Jeff Darabi	800499164	618-650-3382	jdarabi@siue.edu

Department	Campus Box	School College
Mechanical Engineering	1805	Engineering

Course or Program

ME 310 -Thermodynamics I, Mechanical Engineering, Industrial Engineering, and Civil Engineering

Project Co-Director	ID	Department	Email

Student Impact:	60

Multiple Submission Priority:	

Summary:
ME 310 -Thermodynamics I is a required junior-level course for Mechanical, Industrial and Civil Engineering students. This course is a prerequisite for several ME courses and students must complete this course with a grade of “C” or better before they can take higher level courses. Every year, approximately150 students take this course. However, Thermodynamics is a difficult subject and involves a challenging set of abstract concepts such as entropy and exergy that are difficult for students to grasp. Currently, this course is offered in a traditional lecture format. Based on my experience teaching this course for over 10 years and from reports in the literature, I have identified a set of strategies that are critical for mastery of thermodynamics. Thus, the goal of this project is to incorporate practice-oriented studio sessions into this course to help students learn the thermodynamic concepts and laws. We will develop a set of well-designed group exercises and projects throughout the semester in a studio setting that will focus on collaborative and experiential learning. These studio assignments will be connected with the real world to motivate students and to solidify their knowledge of thermodynamic principles. Group exercises and projects will range from analyzing simple real-life examples such as a bicycle pump to more complex systems such as an internal combustion engine. The proposed studio environment is expected to get students actively engaged in directing their own learning and to enhance student motivation and retention in engineering. An outcomes-based survey will be conducted on student

achievement of learning outcomes. In addition, peer and self-assessment strategies and feedback will be incorporated throughout the semester to assess student learning.

Project Budget

Salary	Wages	Travel	Equip.	Comm	CServ	Auto	Tele	Awards	Total
9000	4500	0	0	0	0	0	0	0	13500

Cost-Sharing

Salary	Wages	Travel	Equip.	Comm	CServ	Auto	Tele	Awards	Total
0	0	0	0	0	0	0	0	0	0

1. Current Situation

Thermodynamics I is a fundamental, 3-credit hour course in Mechanical Engineering curriculum. During 2016-2017 academic year, there were158 students enrolled in this course. This course is intended to provide a firm foundation to undergraduate mechanical engineering students in the design and analysis of energy related problems and is a prerequisite for serval ME courses. Students must complete this course with a grade of “C” or better before they can take higher level courses related to the design and analysis of energy conversion devices and systems. Therefore, the course instructor must ensure that students learn important course content and are well prepared to take higher level courses. At present, this course is offered in a traditional lecture format. Creating a studio based learning environment in the engineering field has been the subject of investigation at a number of universities. A number of studies [1-7] have found that innovative teaching programs in core engineering curricula are relatively limited and many universities continue to offer traditional core curricula. However, a number of universities including Cornell University, University of Maryland, Delft University of Technology, and the University of Edinburgh have started to implement studio-based curricula in Engineering.

While studio teaching has been used in the sciences, arts, and design fields, it is not widely implemented in the engineering field. Thus, the objective of this project is to instigate studio based learning environment into the thermodynamics I course at SIUE. This integrated approach challenges students to stretch the learning boundary and extends into knowledge and concepts normally not dealt with in-depth in this course and to provide the necessary tool for a better understanding of the principle thermodynamic concepts such as energy, entropy, and exergy.

2. Proposed Project

Engineering applications of thermodynamics include power plants for generating electricity, engines to run car, trucks and aircrafts, heating, refrigeration and air conditioning systems, to name a few. The proposed course redesign will encourage problem-based experiential learning and design integration in thermodynamics curriculum. We will use many real world examples to demonstrate the principles, and to show how thermodynamic concepts can be used to solve everyday engineering problems. The course will be split into two 1-hour lectures followed by one hour studio session per week. Students will be challenged by a small set of well-chosen group assignments with varied level of difficulty that provides further insight into the concepts and expands the boundary of their thermodynamics knowledge. We will extensively use and integrate the Engineering Equation Solver (EES) in the studio sessions. EES software is a very powerful tool for thermodynamic analysis with built-in functions for thermodynamic and transport properties, allowing students to efficiently explore the solution space for realistic problems, rather than manually solving idealized textbook problems. This software is already available in our department.

Table 1 lists the type of group exercises and projects that will be carried out by students. Each assignment will consist of examining the effect of different parameters and properties on a thermodynamic system, while performing a comprehensive analysis and simulations. We will conduct a series of simulations designed to address targeted concepts using Engineering Equation Solver program. Before discussing and sharing the simulations, students will be asked to predict what will happen if they make a change, such as increasing pressure or raising the temperature. The instructor will then perform simulations so the students can observe how the system behaves in response to those changes and then explain if their prediction was accurate and what effects the change had using results obtained from the simulations. In thermodynamics, students often have misconceptions of physical properties that cannot be easily observed and their understanding becomes abstract. These simulations will allow students to see, in an interactive approach, how the system will behave when the parameters vary and how the phenomenon under consideration can be explained in terms of other measurable macroscopic effects.

A teaching assistant will be needed to help the instructor during the studio sessions since the class size is expected to be large. The enrollment cap on this course is 60 students per section and they normally fill up. The studio objectives and learning outcomes will be communicated to the TA so that he/she may provide effective feedback to the students. Regular meetings will be hold with the TA on the progress of the studio and the TA is encouraged to contribute his/her ideas for teaching and learning and assessment for studios. In studio sessions, the class will be divided into groups of 3-4 students. Lecturing will be limited to 5-10 minutes at the beginning of class to lay out the objectives of the studio and discuss activities that will take place in the classroom. The goal of studio teaching is to get students to be active learners and develop the skills necessary to go on and be successful lifelong learners. Thus, the roles of the instructor and TA are to ensure the students will follow design principles rather than giving step-by-step instructions. After distributing assignments, the instructor and TA will observe and examine students' thinking processes as they work through the projects. It will be stressed that it is the student's responsibility to take charge of their learning and we will only try to help if it is deemed that students need guidance and input to make satisfactory progress and stay on course.

Table 1: A list of sample projects

Project	Description
Bicycle Pump	Calculate work and heat during the process and generate pressure-volume curve for each stroke.
Household Refrigerator	Design requirements to keep the inside of a refrigerator at a certain temperature.
Air Compressor	Illustrates the operation of an air compressor and study the design parameters that affect the power required to operate the compressor
Internal Combustion Engine	Determine the necessary design requirements for how the temperature, bore diameter, RPM, and compression ratio affect engine power and efficiency
Phase Change	Simulate phase change in a piston-cylinder device.
Power Plant	Design a power plant and study the effects of certain input parameters on the efficiency and performance of the system.

Table 2: Timeline for the proposed project

Period	Planned Activities
July 1-August 15, 2018	Design studio assignment topics Design and develop simulations for the projects Design rubrics, surveys and assessment plan
August-December 2018	Implement studio teaching Make mid-course corrections if needed
January -May 2019	Revise and refine studio activities and materials based on assessment results and students' feedback
June 2019	Prepare and submit a final report to EUE Coordinator

3. Evaluation and Dissemination

The studio environment will make it possible to analyze challenging problems in great depth, thus promoting higher levels of learning. To provide a high level of learning for all students, it is necessary to review and discuss learning outcomes at the end of each exercise or project. The results of these evaluations will be constantly utilized to improve the studio assignments and make mid-course corrections if they are needed. In addition a mid-semester survey and an end-of-semester evaluation will be conducted to make adjustments and improvements in studio teaching.

A mid-semester student survey will be designed to determine to what degree the studio sessions have increased students' knowledge and understanding of the thermodynamics laws and concepts. An end-of-semester survey will be tailored to provide a quantitative analysis of studio instruction of what was done in studio sessions to objectives set by the instructor on the various assignments. Finally, at the end of the course, a formative assessment will be conducted to measure the student's learning outcomes. This assessment will be compared with students' perceptions of studio teaching's contribution to the achievement of the learning outcomes to determine how well the students' perceptions match those of the instructor. The developed simulation programs and group projects will continue to be maintained and used in ME 310 in future semesters. Finally, all assignments, projects, and simulations developed during the course of this project will be made available to faculty colleagues who will teach this curse in the future.

Budget and Budget Justification

Itemized Budget Table

	Item	Request
1.	Faculty salary	$9,000.00
2.	Graduate student	$4,500.00
Total		**$13,500.00**

The proposed course requires extensive preparation in terms of designing assignments and projects, developing computer programs and simulations, and assessment surveys. The project will require 3 to 4 weeks of PD's summer effort to effectively prepare the course materials. As mentioned in the narrative, the PD must identify and develop approximately 6-8 well-designed group exercises and projects that are broad and stem from thermodynamic principles, and are applicable to real world problems. The PD must then perform analysis and develop simulations for each project. The PD must also provide a training to a teaching assistant and communicate the studio objectives and learning outcomes so that he/she may provide effective feedback and help students who struggle to make progress during studio sessions. Since the class size is expected to be large in the Fall 2018 semester, a teaching assistant will be needed to help keep classroom running efficiently and answer students' questions during studio sessions, and grade assignments. Thus, funds are requested for a graduate student for 4.5 months at 50% effort. The requested PD salary and student wage support are essential to complete the proposed EUE goals.

References

1. Nasr, K.J., J.S. McDonald, W.L. Scheller II, Development of a common core curriculum for all engineering students, ASEE-NCS 2000 Spring Conference, March 30-April 1, 2000.
2. Perkins, D., The Case for a Cooperative Studio Classroom: Teaching Petrology in a Different Way, Journal of Geoscience Education, v. 53, p. 101-109, 2005.
3. Berglund, A. Do we facilitate an innovative learning environment? Student efficacy in two engineering design projects, Global Journal of Engineering Education 14 (1), 27–33, 2012.
4. Flores, P, How do mechanical engineering students see their training and learning at university? Findings from a case study, Global Journal of Engineering Education 14 (2), 189–195, 2012.
5. Lambert, C., Basini, M. and Hargrave, S. (2008) The activity led learning within aerospace at Coventry University, Engineering Education 14–16 July 2008. Loughborough, UK.
6. Perrenet, J., Boujhuijs, P. and Smits, J., The suitability of problem-based learning for engineering education: theory and practice, Teaching in Higher Education 5 (3), 345–358, 2000.
7. Hagler, M.O. and W.M. Marcy, Strategies for Designing Engineering Courses, Journal of Engineering Education, 88 (1), January, ASEE, 1999.

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Education

Ph.D., Mechanical Engineering, University of Maryland, 2000
M.S., Mechanical Engineering, University of Maryland, 1997

Employment

2017-present	Professor, Dept. of Mechanical Engineering, SIUE
2012-2017	Associate Professor, Dept. of Mechanical Engineering, SIUE
2010-2012	Research Scientist, Dept. of Mechanical and Aerospace Engineering, University of Florida
2007-2010	Adjunct Professor, Dept. of Mechanical Engineering, University of South Carolina
2007-2009	Technical Manager, CytomX Biosystems, Santa Barbara, CA
2001-2006	Assistant Professor, Dept. of Mechanical Engineering, University of South Carolina
2000-2001	Assistant Research Scientist, Dept. of Mechanical Engineering, University of Maryland

Honors and Awards:

2017	Outstanding Teacher in the Department of Mechanical Engineering
2016	Outstanding Researcher in the Department of Mechanical Engineering
2014	Outstanding Teacher in the Department of Mechanical Engineering
2014	Outstanding Researcher in the Department of Mechanical Engineering
2013	The Annette and Henry Baich Award
2013	Disability Awareness Appreciation Award
2005	ASHRAE New Investigator Award
2004	Outstanding Research Team at the SCAMP Summer Undergraduate Research Conference
2004	USC Research and Productive Scholarship Award
2002	Pi Tau Sigma Mechanical Engineering Professor of the Year Award
1999	The Homer Addams Award
1999	University of Maryland Outstanding Student Award
1998	ASHRAE Grant-in-aid Fellowship Recipient
1995	ASHRAE Grant-in-aid Fellowship Recipient
1994	Ranked first in the graduating class

Selected Publications (form a list of over 70)

1. Golozar, Matin, Molki, M., **Darabi, J.**, Computational and performance analysis of a continuous magnetophoretic bioseparation chip with alternating magnetic fields, J. Microfluid Nanofluid (2017) 21: 73. https://doi.org/10.1007/s10404-017-1909-4.
2. **Darabi, J.** and C. Guo, Continuous isolation of monocytes using a magnetophoretic-based microfluidic Chip, Biomedical Microdevices, 18 (5), 1-10 (2016), DOI 10.1007/s10544-016-0105-8.
3. Gholami Derami, H, Vundavilli, R., **Darabi**, J., Experimental and computational study of gas bubble removal in a microfluidic system using nanofibrous membranes, Microsystem Technologies (2016), DOI 10.1007/s00542-016-3020-2
4. Ghanbari, S. and **Darabi, J.**, Fabrication and Material Characterization of Copper and Copper-CNT Micropillars, Mater. Res. Express 2 (2015) 075501.
5. Hale, C. and **Darabi, J.**, Magnetophoretic-based microfluidic device for DNA isolation, Biomicrofluidics 8, 044118 (2014); doi:10.1063/1.4893772.

6. Ghajar, M. and **Darabi, J.**, Evaporative Heat Transfer Analysis of a Micro Loop Heat Pipe with Rectangular Grooves, International Journal of Thermal Sciences, 79 (2014), 51–59.
7. **Darabi, J.** and C. Guo, On-chip magnetophoretic isolation of CD4+T cells from blood, Biomicrofluidics 7, 054106 (2013); doi: 10.1063/1.4821628.
8. Sen, A K, **Darabi, J**, Knapp, D R, Aerosol formation in electrospray ionization using a microfluidic emitter, *IEEE Sensors Journal*, 11 (2011) 2335-2341.
9. Sen, A K, **Darabi, J**, Knapp, D R, Analysis of droplet generation in electrospray using a carbon fiber based microfluidic emitter, *ASME J Fluids Engineering*, 133 (2011) 1-8.
10. Sen, A K, **Darabi, J**, Knapp, D R, A fluidic interconnection system for polymer based microfluidic devices, *J. Microsystem Technologies*, 16 (2010), 617-623.

Patents

1. **Darabi, J.**, and Ohadi, M. M., "Electrohydrodynamically Enhanced Micro Cooling System for Integrated Circuits," US Patent # 6,443,704.
2. Chang-Yen, D., **Darabi, J.**, Zhang, Y., and Pagano, P., Trapping Magnetic Sorting System for Target Species, US Application # 12/197,169, Patent pending
3. Chang-Yen, D., **Darabi, J.**, Zhang, Y., and Pagano, P., Trapping Magnetic Cell Sorting System, US Application # 12/933,395, WO 2009/117611 A2, Patent pending
4. Chang-Yen, D., **Darabi, J.**, Zhang, Y., and Pagano, P., Magnetic Separation System With Pre and Post Processing Modules, US Application # 12/937,983, WO 2009/129415 A1, Patent Pending
5. **Darabi, J.**, Nano Hot-tubes for High Resolution Measurements of Flow and Temperature in Microfluidic Devices, Invention disclosure filed.

Professional Societies

- Member of American Society of Mechanical Engineers (ASME)
- Member of the Institute for Electrical and Electronics Engineers (IEEE)
- Member of Pi-Tau-Sigma Mechanical Engineering Honor Society

Service and Synergistic Activities

- Associate Editor of Heat Transfer Engineering Journal
- Track organizer/Session chair at ASME International Mechanical Engineering Congress & Exposition, ASME Summer Heat Transfer Conferences, ASME International Conferences on Nanochannels, Microchannels and Minichannels, and IEEE ITHERM Conferences
- Reviewer for over 20 journals and Research Proposals for NSF, AFOSR, and US DOE
- Mentor undergraduate research assistants through the SIUE Undergraduate Research and Creative Activities (URCA) and Meridian and Honor Scholars
- Mentored and supervised high school students through summer program for research interns (SPRI) organized by the South Carolina Governor's School
- Supervised minority undergraduate students through South Carolina Alliance for Minority Participation (SCAMP) program and African American Professors Program (AAPP)

To: Excellence in Undergraduate Education program

From: Majid Molki, Chair, Department of Mechanical and Industrial Engineering

Subject: Suppoet Letter for EUE Proposal

Date: January 26, 2018

I am writing this letter to give my full support of the EUE proposal submitted by Professor Jeff Darabi. The proposed work is intended to revise the way the first course of thermodynamics is offered to undergraduate students and to bring some experiential learning component to this traditional course. I anticipate the new approach would have a positive impact on the way thermodynamics is taught in the mechanical engineering program at SIUE.

Thermodynamics is a two-course sequence in the mechanical engineering curriculum. The first course, ME 310 – Thermodynamics I, covers the fundamental concepts, while the second course, ME 312 – Thermodynamics II, is focused on applications. Both courses are required in the mechanical engineering program. The proposed teaching plan is inteded to make thermodynamics more palatable and exciting to students by including hands-on and experiential learning components in a virtual environment using Engineering Equation Solver (EES) software. This approach will motivate and encourage students to better absorb the concepts of thermodynamics and to relate to the subject through applications.

Professor Darabi has implenmented a similar approach in ME 312 – Thermodynamics II, and it has been very successful. Expanding this method to ME 310 – Thermodynamics I is more challenging, because of the larger enrollment, and the demand for more resources such as the instructor's time and assistance from teaching assistants. With this EUE funding, I am confident that the mechanical engineering program will benefit from the proposed effort, and it will be a major step in providing better education to our students.

Date: January 26, 2018

To: EUE Review Committee

From: Cem Karacal, Dean, School of Engineering

Subject: EUE Proposal Submitted by Dr. Jeff Darabi

I am writing this letter in support of Dr. Darabi's EUE proposal. The focus of Dr. Darabi's proposal is to incorporate studio sessions into a first course in Engineering Thermodynamics. Thermodynamics is one of the most fundamental and difficult to teach courses in the mechanical engineering curriculum. Dr. Darabi plans to engage students in collaborative learning and provide an experiential learning component that is not possible through traditional lecturing. The proposed redesigned course will provide the inclusion of real-world analysis and simulations into the course, thus, expanding opportunities for experiential learning. Dr. Darabi has developed and redesigned several other successful courses for the mechanical engineering department and his students find his teaching style and delivery method interactive and stimulating. I believe the proposed redesigned course will be similarly successful.

I enthusiastically endorse this EUE application.