STIMULATING STUDENT INTEREST USING AUTOMOTIVE SYSTEMS

Olakunle Harrison

Mechanical Engineering Department
Tuskegee University, Alabama

Abstract

The subject of automotive systems remains an enduring area of great interest to many mechanical engineering students. This paper presents a pilot mechanical engineering course that stimulates student interest to a high degree. Significant advances in engineering methods, tools, and practices over the years have resulted in tremendous quality improvements in the production of consumer goods. While this trend is desirable and strenuously pursued by the engineering community, the implication for mechanical engineering is that students will have less exposure to the inner workings of machines, devices and their components. Simply stated, if it doesn't break down, it won't need fixing or investigating. Many mechanical engineering programs now have a Mechanical Dissection course to address this lack of exposure to the inner workings of representative consumer products. Many students love the automobile and want to know how its subsystems function. Students show heightened levels of interest when examples involving the automobile are used during instruction. Clearly, much engineering knowledge can be transferred through the use of examples and case studies within a framework to which students can relate. We at Tuskegee University are using automotive systems applications as a foundation for teaching a variety of engineering concepts and methods. To this end a course in which students immerse themselves in the fundamentals of automobiles has been developed. This 3-hour senior elective course entitled Automotive Systems Design serves as an exciting platform for introducing various applications of engineering principles. The main topics of the course are vehicle performance, powertrain, suspension, and braking. A survey of students taking the course indicates a high level of interest in the course. One indicator of student interest is the approximately four-fold increase in the number of questions asked during lectures.

Introduction

Quality improvements over the past two decades have resulted in significant increases in the longevity and reliability of consumer products. Additionally, many products to which the current generation of engineering students is exposed are composed of complex, non-serviceable components. A consequence of this trend is that many mechanical engineering students lack a basic knowledge of how things work not having had many opportunities to tear down and attempt to repair a variety of devices. The number of mechanical engineering programs that have developed a freshman/sophomore level Mechanical Dissection course to address this deficiency underscores the importance of this issue.

The automotive industry's offer of longer warranty periods on its products as well as guarantees of 100,000 miles without any scheduled maintenance are no longer novel. While this is good news for consumers, it is also a guarantee that most students will not get to investigate, repair, or even discuss problems with their automobiles. Thus, the possibility of learning engineering within this context is greatly diminished. Because the automobile remains a subject of great interest to many mechanical engineering students, the author uses many automotive related examples in discussions, assignments, and projects to great advantage in securing and maintaining students' interest.

A senior-level automotive systems design course as well as other synergistic activities have been developed at Tuskegee University to harness student interest in automobiles. The main goal of the course is to introduce engineering concepts, principles of operation, and design considerations in a framework with which students are familiar and have above average interest. This situation-approach to engineering education means that the learning process is at the outset given a setting of reality[1]. Lindeman[1] states that the resource of highest value in adult education is the learner's experience. Thus, we can expect that engineering concepts can be better taught using a platform such as the automobile.

The course described herein is currently listed in the university's catalog as a Special Topics course. One major benefit of this course is the exposure to material that students would otherwise miss in the standard curriculum. For example, some concepts of mechanical vibrations are taught using suspension systems as the "learning environment." As another example, the subject of power transmission is discussed with using a variety of examples in an automobile's power train and other auxiliary systems. Care is taken to continuously relate engineering concepts to applications outside the automotive arena.

An automotive systems laboratory supports the automotive systems design course. As part of the course, students get to disassemble a modern (1996 GM Northstar) V-8 engine and identify each subassembly and component. Selected subsystems of the engine are then reverse-engineered as class assignments. The laboratory houses an electric vehicle and contains a variety of other automotive sub-assemblies for students to study. Students complete one design project in the course. They get to design a major subsystem for Tuskegee University's SAE Mini-Baja contest vehicle.

A survey of students taking the course indicates a substantially high level of interest in the course. One indicator of the level of student interest in the course is the increased number of questions asked during the lecture – at least a four-fold increase when compared to other courses the author teaches. The nature of the questions asked indicates familiarity with the overarching issues being discussed as well as a genuine desire to know.

Course Outcomes

The automobile is replete with a host of subsystems some of which, by themselves, would take an entire semester or more to teach and learn in depth. It is not the goal of this course to make, for example, engine designers, out of students; we do not expect that a new hire in the automotive industry would be given major engine design responsibilities. Consequently, the course content reflects topics in which the student might already have some background and concepts that the typical new graduate is likely to encounter in industry - automotive as well as non-automotive. Students learn how engineering theory is applied in an already familiar context. They are introduced to some of the practical considerations involved in the design of automotive systems, for example, mathematical models, determination of system loads, design life, safety issues, factors of safety, and weight reduction strategies in component design.

Table I shows the course outcomes areas as well as the desired level of competency for the course. For the most part, each outcome has been chosen for its applicability to both automotive and non-automotive systems, while seeking to maintain student interest with automotive-related concepts. Thus, the subject of powertrain seeks to reinforce, through applications, the elements of power transmission learned in a Machine Design course.

Table I: Automotive Systems Design Course Outcomes & Competency Expectations

OUTCOME AREAS	Intro	Analysis	Synthesis
Engine Fundamentals and Operation	X		
Engine Types and Configurations	X		
Vehicle Dynamic Performance	X	X	
Powertrain	X	X	
Suspension Systems	X	X	X
Steering Systems	X	X	X
Braking Systems	X	X	

The textbook used in the course is Fundamentals of Vehicle Dynamics by Thomas Gillespie.

Course Assignments and Design Project

One of the difficulties of a course such as automotive systems design course is in developing assignments that are manageable with respect to the time available and the effort and background required. In order to expose students to a variety of automotive applications of engineering theory, it has been necessary to limit assignments to relatively straightforward problem-solving exercises. For example, one assignment involved analyzing input and output velocities of an automatic transmission's planetary gear system.

A more involved assignment dealt with the determination of a vehicle's acceleration as a function of velocity given torque data at various engine speeds while taking into account factors such as engine and drive train inertia, as well as aerodynamic drag. The assignment is done using the Excel spreadsheet with flexibility for changing parameters to reflect conceptual design phase inquiries. Students are required to fit a curve to the given data and account for drops in engine speed at the transmission shift points.

The last six weeks of the course is devoted to suspension systems culminating in a suspension system design project. The project is driven by the need to build a vehicle to participate in the Society of Automotive Engineers annual Mini-Baja contest. Thus, students in the course are assigned the task of designing the vehicle's suspension system. Two teams of students are assigned the front and rear suspension. The students are required to develop their product design specifications, conceptual designs, and computer models for their suspension design. A computer model was developed using the Working Model 2-D software. Students in the course interact with members of the SAE student section already working on the vehicle.

A Problem-Based Learning Approach

There remains a need for closure in the theory-application-familiar example loop. The students, all seniors, in the course commented that this was the first course in which they were required to actually "apply" their knowledge of engineering theory. They also displayed a lack of familiarity with some engineering terminology, even though they had been exposed to a majority of the underlying concepts in other courses. Elements of the problem-based approach used in varying degrees in this course help to reinforce the student's knowledge of engineering principles and their applications. These elements include: (1) Problems as a Vehicle for the Development of Problem-Solving Skills; (2) Learning That Is Student Centered, and; (3) Small Learning Groups[2]. By using a variety of learning activities including tear-down exercises, observation of actual automotive parts, reverse engineering, and simulations obtained from the World Wide Web, the instructor is able to devote much more time during the class meeting to discussing key issues and answering questions than possible in the traditional lecture method alone[3].

This course is a Special Topics course with goals that include exposing students to material they would otherwise miss in the standard mechanical engineering curriculum. For example, Vibrations is not currently a required course in our curriculum. Thus, the study of suspensions offers an excellent opportunity and context to present a rudimentary introduction to single- and two-degree of freedom vibratory systems and the motion characteristics of forced, damped systems. Students relate very well to phenomena such as resonance, under- and over-damping, system response away from resonance, and the influence of various masses on suspension behavior. Their personal experiences serve them very well in understanding these phenomena.

The Automotive Systems Laboratory and Learning Environment

The automotive systems laboratory at Tuskegee University was developed with a grant from the Ford Foundation. The laboratory is an 800-sq. ft. facility with an engine test cell that will house an engine dynamometer. The rest of the laboratory is used for the engine disassembly exercise in the course and to display a variety of automotive related components. The course is taught in a classroom adjacent to the laboratory and thus enjoys the benefits of co-location.

We envision the automotive systems laboratory to be a pivotal facility in our Mechanical Engineering program. Figure 1 shows a relationship between various automotive systems and selected mechanical engineering courses and how an automotive systems laboratory can support and enhance instruction. The lab provides a host of subassemblies that can be used for

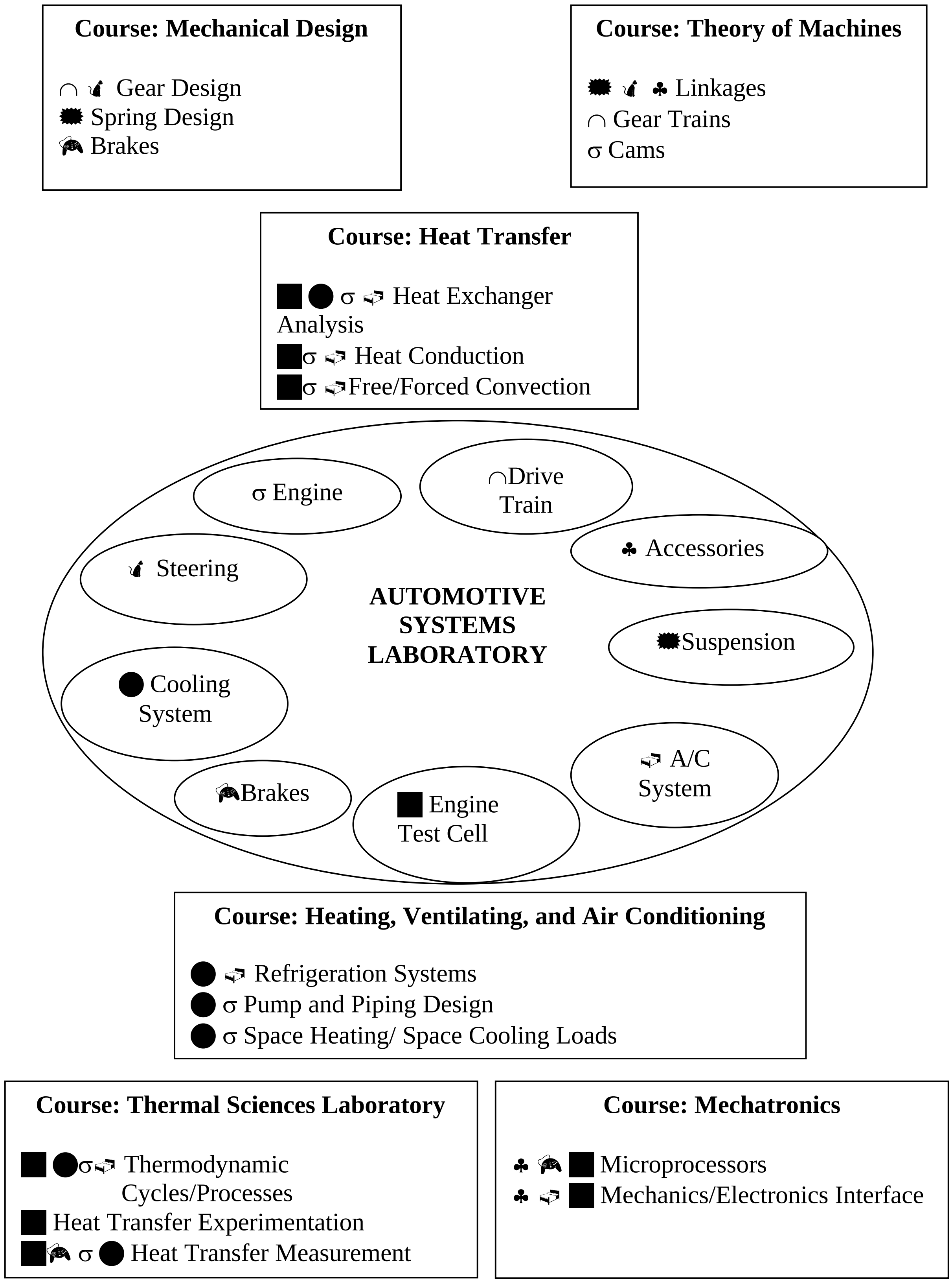

Fig. 1: Possible Impact of Automotive Systems Lab Components on ME curriculum

homework assignments, projects, or simply demonstration. For example, in our Theory of Machines course, students get to analyze the motion of a front wiper assembly linkage. The linkage is available to the class as a modular, functional assembly, so students get to observe the wiper assembly in operation. Obviously, issues related to the three-dimensional nature of linkage motion are easier to describe and observe with an actual assembly than in a 2-D setting.

The positive influence of the Society of Automotive Engineers (SAE) annual Mini-Baja competition on engineering students is far reaching. Tuskegee University students are embarking on this journey by entering a vehicle in the contest. Students use the laboratory for constructing their contest vehicle.

The automotive systems laboratory also houses an electric vehicle, the EV1, donated by General Motors. The EV1 is a limited production vehicle that went into service in 1996. The car is used in the lab for demonstration purposes with students learning about its various design features, especially, those related to energy consumption.

Tuskegee University belongs to an industry/university consortium called Partners for the Advancement of CAD/CAM/CAE Education. This international consortium seeks to advance the use of CAE tools in engineering education at a number of universities with significant relationships with General Motors. The industry partners include GM, EDS/UGS (Unigraphics), Mechanical Dynamics, and Sun Microsystems. Some of the PACE universities include Michigan State University, University of Missouri-Rolla, Prairie-View University, University of Mexico, and University of Toronto.

Through the PACE program we have access to a database of scores of Unigraphics models for use for in-class demonstrations and exercises. The models consist mainly of automotive parts and assemblies that show students what automotive systems and parts look like and how they are assembled. The value of these ready-made models is significant, as we in the university community would have great difficulty developing so many realistic models with such detail.

Another important use of the automotive systems laboratory at Tuskegee is for motivating K-12 students to consider engineering. The sight of college students close to their age in action and producing “something useful” will be a source of encouragement to pursue engineering, hopefully mechanical engineering.

Challenges

One of the prime indicators of student interest in the automotive systems design course is the abundance of questions they ask. Because of this interest and probing, it is very easy for discussions to digress to other, albeit related, issues. Consequently, it is absolutely necessary that the instructor keep the discussions on track relative to the learning objectives for each session. Most of the students want to know why something occurs under certain conditions in their cars, or why manufacturers don’t design certain systems to produce some benefit or other. In most cases, it is imperative that the instructor give short answers and return to the topic at hand, otherwise the goals of the course will not be met. On the other hand, it is important that the instructor create and promote a positive, optimistic, success-oriented environment; thus, the instructor should provide some answer to each student question[4].

Future Work

In the future we plan to incorporate some of the design tools used in industry such as Failure Mode and Effects Analysis. This subject will be taught using case studies from industry. We also plan to acquire an engine dynamometer for providing an experimental component to this course, albeit a limited, but interesting one. It is anticipated that a dynamic test such as an engine test will provide additional opportunity for teaching another important component of the engineering function, that of testing and verification.

Conclusions

This paper describes a pilot course in Automotive Systems Design as well as synergistic activities that are being used to enhance and motivate student learning in mechanical engineering. Fewer students now enter the mechanical engineering curriculum with a basic understanding of how things work. Much effort has been directed at Mechanical Dissection classes for underclass students. In order to sustain student interest and enthusiasm for the field, engineering faculty must continue to utilize innovative and exciting teaching methods. The context, or learning environment, within which teaching occurs plays a major role in the quality of student experience. Industry's demands for skilled engineers, especially for the design function, will only be met by providing students with a rich learning environment where the applications of engineering principles can be seen and understood with relative ease.

The diverse nature of automotive systems topics allows adaptation of the course to suit individual faculty interests. Thus, the course could be offered every semester while rotating between faculty members. Our experience with the Automotive Systems Design course indicates that engineering principles and concepts can be communicated effectively in a "comfortable" and familiar context such as found in the automobile. A survey of the students taking the class indicated unanimous support for the course.

Acknowledgements

The automotive systems laboratory at Tuskegee University was constructed using funding from the Ford Foundation. In addition, Ford Motor Company engineers have contributed to the automotive systems design course through course design input, class visits, and project support. The electric vehicle, as well as automotive parts, for the laboratory was donated by General Motors. The contribution of computers and software by PACE partners – General Motors, EDS/UGS, Mechanical Dynamics, and Sun Microsystems – have provided us with state-of-the-art tools for enhancing student learning in our curriculum.

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Biography

OLAKUNLE HARRISON
Olakunle Harrison is an assistant professor at Tuskegee University in Alabama and teaches mechanics, automotive systems design, machine design, capstone design, mechatronics, and design for manufacturing. A graduate of the University of Tennessee, Knoxville, his research interests are in engineering design, automotive systems, mechatronics, product development, and design for manufacturing. He is a licensed professional engineer.