Effect of Personal Contact in Improving the Outcome of Minority Engineering Students

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Abstract

The Accreditation Board for Engineering and Technology (ABET) has set up some criteria, which the graduates of all accredited engineering programs must satisfy. In addition to the ABET requirement, the Mechanical Engineering (ME) program at Alabama A&M University has been designed to meet some additional requirements by the American Society of Mechanical Engineers. The Faculty at Alabama A&M University adopted the SEAARK teaching method. SEAARK stands for Knowledge, Repetition, Application, Analysis, Evaluation and Synthesis in reverse order. In the past few years, mapping of course contents to SEAARK teaching methods and above-mentioned ABET and additional ME program criteria has been completed. Outcome based course assessment tools have also been identified and mapped.

This paper studies the effect of personal level contact by Faculty with the students, especially minority black students. A case study is presented using the data for Thermodynamics course. The course contents are mapped to the above mentioned ABET and additional criteria. The outcome is measured and compared using the above mentioned assessment tools. Black engineering students are highly under-represented with respect to all engineering students and percentage of their population. It is shown that, frequent faculty-student contact in and out of class, expressing faculty concern about the students problems, especially those who miss class frequently, trying to help with their studies, sharing experiences and attitudes with the students, help these students to get through their rough or difficult times and move forward to achieve their career goals. The percentage increase of student overall learning performance due to personal contact, measured using the above outcome assessment tools, in turn demonstrates the percentage increase in satisfying the ABET criteria, the desired goal. Personal contact also improves student retention and will help to increase the percentage of minority black engineers in future.

1. Background

Alabama Agricultural and Mechanical University (AAMU), a historically black university, reflects the uniqueness of the traditional land-grant institution, which combines professional, vocational and liberal arts pursuits. The University provides baccalaureate and graduate studies that are compatible with the times to all qualified, capable individuals who are interested in further developing their technical, professional, and scholastic skills and competencies. A center of substance and excellence, Alabama A&M University provides a setting for the emergence of scholars, leaders, thinkers, and other contributors to society. AAMU is located in Huntsville, Alabama, which is known internationally as a center of aerospace and defense technology. Huntsville is considered as a leader in high-tech research, engineering services, information systems design and in the manufacturing of computing equipment, telecommunications, space vehicles and rocket propulsion. It is the home of more than 50 Fortune 500 companies. These industries and government agencies require a large number of qualified engineers in the areas of manufacturing and propulsion.

The Mechanical Engineering (ME) program at Alabama A&M University started in 1997, as a result of a desegregation lawsuit. The program was designed for full implementation to occur five years after the start date. The program encompasses the traditional roles of Mechanical Engineering in areas of analysis, design, manufacturing, and testing of mechanical and thermal systems, while also including system integration, propulsion systems, concurrent engineering, and other competitive manufacturing practices. Based on the local demand, the program has two options: Manufacturing and Propulsion. The Mechanical Engineering Department at AAMU is committed to prepare students in these options, to work efficiently for various industries and government.

The basic criteria of Accreditation Board for Engineering and Technology (ABET) for the engineering program's outcome and assessment requires that graduates must have demonstrated abilities (ABET Criteria 3, a-k [1]), in mathematics, science, engineering, design, data analysis, teamwork, ethics, communications, and life-long learning. In addition to ABET 3(a-k) requirements, the Mechanical Engineering program at AAMU was designed to meet the additional requirements of the American Society of Mechanical Engineers, such as (l) an ability to apply advanced mathematics through multivariate calculus and differential equations, (m) a familiarity with statistics, linear algebra and reliability, (n) an ability to work professionally in both thermal and mechanical systems areas including the design and analysis of such systems, (o) a knowledge of contemporary analytical, computational, and experimental practices, (p) a competence in experimental design, data collection, and data analysis, (q) a competence in the use of computational tools, (r) knowledge of chemistry, and (s) knowledge of calculus-based physics.

The Mechanical Engineering Faculty at AAMU revised the course contents to satisfy the above criteria (a-s). Each course contents were mapped to the above (a-s) requirements. Although each course does not satisfy all the (a-s) requirements, the overall ME curricula provide the (a) through (s) training. The Mechanical Engineering program at AAMU was successfully accredited by ABET in Summer 2000 and again in Fall 2002.

2. Assessment Tools

The educational objective of the Mechanical Engineering program is to provide students with the necessary preparation in Mechanical Engineering to compete effectively for professional careers in this field and with the motivation for personal and professional growth through life-long learning.

The objective of each course has to be designed to meet the overall ME program objective. Also, based on the mapping of course content with criteria (a-s), the outcome of each course has to be measured.

In the following sections, ME 310 Thermodynamics class will be discussed as an example. This course is designed to provide the student a basic working knowledge of engineering thermodynamics with the inclusion of open-ended problems in the design of thermal systems and consideration to the thermodynamics of thermal systems. The student will be able to identify the parameters that characterize the operation of vapor power systems and gas power systems. At the end of the course the student are expected to learn at a level of analysis and synthesis, i.e. beyond repetition. Computer programs will also be developed to support open-ended problems that include basic characterization of thermodynamic systems and basic trade off analysis of a power generation system. The Mechanical Engineering Faculty at Alabama A&M University adopted the SEAARK teaching method [2,3,4]. SEAARK stands for Knowledge, Repetition, Application, Analysis, Evaluation and Synthesis in reverse order. In the past few years, mapping of course contents to SEAARK teaching methods and above-mentioned ABET and additional ME program criteria (a-s) has been completed. The course content for ME 310 is shown in Table 1, and they are mapped to criteria (a-s) in Table 2.

Table 1. Thermodynamics (ME 310) Course Contents.

#	**Course Topic**
1	Thermodynamic systems, and fundamental concepts (Property, state, process and equilibrium). Brief review of system of units. Methodology to solve thermodynamic problems. Engineering design.
2	Energy systems and first law of thermodynamics. Concepts of energy, mechanical methods for energy transfer, energy transfer by heat, energy of a system, energy balance, analysis of energy of simple thermodynamic systems.
3	Properties of pure and simple compressible substances. The state postulate, P-V-T relations for perfect gas, property data of thermodynamic systems, P-V-T relations for not perfect gas, comparison with the ideal gas model.
4	Control volume approach to energy system analysis. The general conservation equation for a control volume, continuity, momentum and energy. Steady state and transient analysis, thermodynamic definition of heat, review of first law of thermodynamics for an open system. Enthalpy as a thermodynamic property.
5	Energy systems and second law of thermodynamics. Entropy and the quality of energy available. Other statements about entropy. Irreversible and reversible processes. Second law and thermodynamic cycles. Absolute zero, absolute entropy, the third law of thermodynamics. Maximum performance measures for power, refrigeration and heat pump cycles operating between two reservoirs.
6	Entropy and design of power system components. Entropy change for

	compressible substances. Entropy change in reversible processes. The entropy balance for closed and open systems. The isentropic process. Thermodynamic efficiency of turbines, nozzles, compressors and pumps. Heat transfer and work in internally reversible steady state flow process.
7	Available energy analysis and thermodynamics of vapor power systems, Rankine cycles, regenerative vapor power cycle, cogeneration, case study, availability analysis of a vapor power plant.
8	Available energy analysis and thermoeconomics of gas power systems. Air standard Otto cycle, diesel cycle, Brayton cycle. Regenerative gas turbines, gas turbines for aircraft propulsion, combined gas turbine-vapor power cycle. One dimensional steady flow in nozzles and diffusers. Flow in nozzles and diffusers of ideal gases with constant specific heats.
9	Basics of refrigeration and heat pump systems.

Table 2. Mapping of the Thermodynamics (ME 310) Course Contents to Criteria (a-s).

Topic	ABET Criteria 3(a-k) and additional ME Program Criteria (l-s)																	
#	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s
1	x		x	x	x	x			x		x	x			x	x	x	x	x
2	x	x	x		x		x				x				x		x		
3	x	x	x		x						x				x	x	x		
4	x	x	x		x						x	x			x		x		
5	x	x	x		x				x		x	x			x		X		
6	x	x	x	x	x			x			x	x		x	x		x	x	
7	x	x	x		x						x			x		x			
8	x	x	x		x	x			x	x	x		x	x			x	x	
9	x	x	x	x	x	x					x			x					

ABET Criteria 3(a-k) and ME Program Criteria (l-s)

a. an ability to apply knowledge of mathematics, science and engineering;
b. an ability to design and conduct experiments, as well as to analyze and interpret data;
c. an ability to design a system, component, or process to meet desired needs;
d. an ability to function in multidisciplinary teams;
e. an ability to identify, formulate and solve engineering problems;
f. an understanding of professional and ethical responsibility;
g. an ability to communicate effectively;
h. the broad education necessary to understand the impact of engineering solutions in a global and societal context;
i. a recognition of the need for and an ability to engage in life-long learning;
j. a knowledge of contemporary issues;
k. an ability to use the techniques, skills and modern engineering tools necessary for engineering practice;
l. an ability to apply advanced mathematics through multivariate calculus and differential equations;
m. a familiarity with statistics, linear algebra and reliability;
n. an ability to work professionally in both thermal and mechanical systems areas including the design and analysis of such systems;
o. a knowledge of contemporary analytical, computational, and experimental practices;
p. a competence in experimental design, data collection, and data analysis;
q. a competence in the use of computational tools;
r. knowledge of chemistry;
s. knowledge of calculus-based physics.

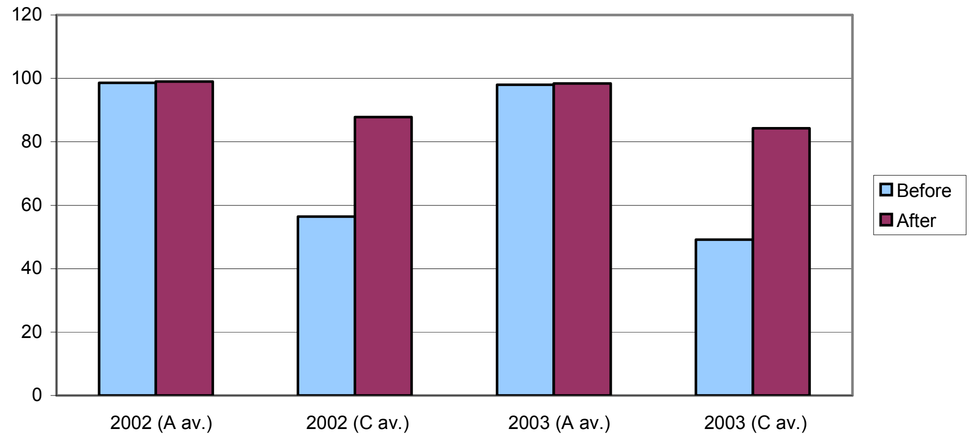
Various outcome based course assessment tools have also been identified [5], which includes Homework assignments, Quizzes, Exams, Class attendance, Design Project, and Computer Simulation.

3. Effect of Personal Contact

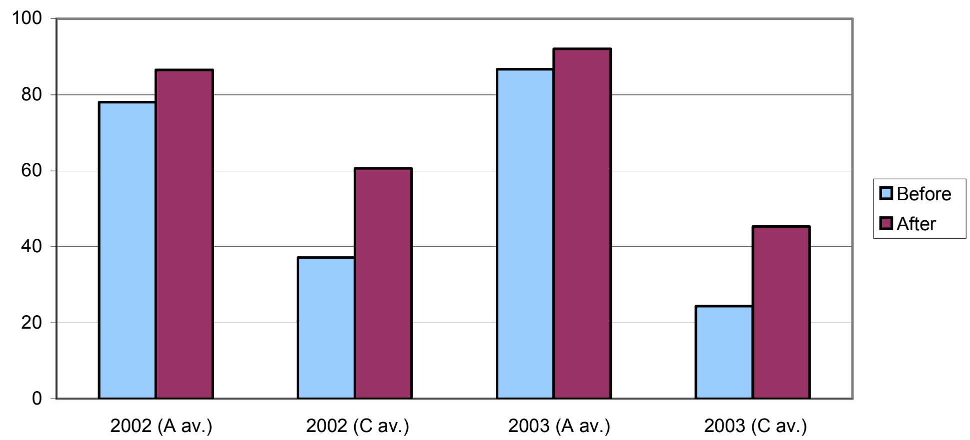
The Thermodynamics course outcome has been measured using the above tools for the last two years and presented in Figures 1(a) through 1(c). Each semester, after the first exam, students who received low grades were identified, and most of the time they were found to be those having low class attendance. Frequent personal contacts were then made with these students, inside and outside the class, expressing concern about their problems and trying to help them with their studies. Extra study sessions were also scheduled. Advising and sharing of experiences were provided to increase their motivation. Data for A-averaged and C-averaged students are plotted, both before and after the personal level contact and counseling, for the year 2002 and 2003. In Fig. 1(a), it is found that initially the C-averaged students had very low class attendance. But after personal communication this improved significantly. From Fig. 1(b), it is observed that after personal contact, the homework and quiz grades for the C-averaged students increased significantly, compared to those before contact, though it is still much lower than the A-averaged students. Fig. 1(c) plots the examination grades for the A-averaged and C-averaged students, before and after the personal level contact, for both 2002 and 2003. It is observed that personal contact helps to increase the class attendance for C-averaged students and consequently improves the Homework, Quiz and Exam grades. As the projects were usually due after the counseling started, so they are not plotted here. Previously [5], it was shown that the student overall learning performance could be calculated as,

$$\text{Student Performance} = a_1 \times \text{Attendance} + a_2 \times \text{Homework} + a_3 \times \text{Exams} + a_4 \times \text{Projects},$$

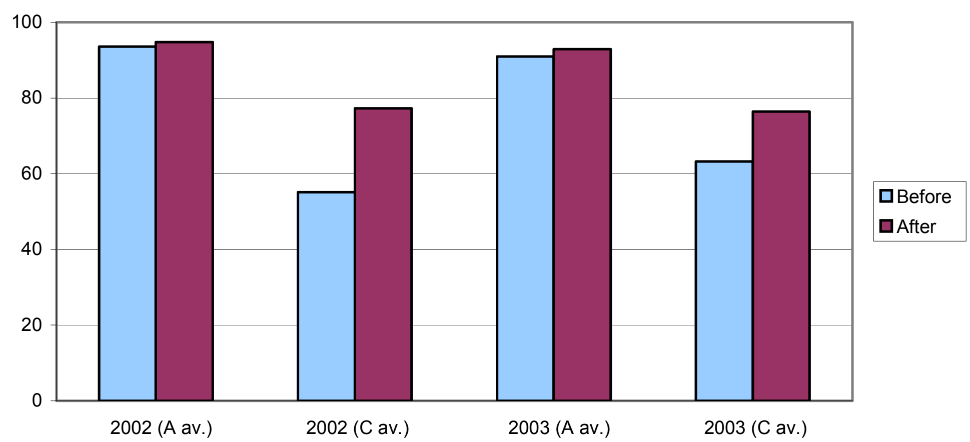
where a_1=5%, a_2 =15%, a_3 =60%, a_4 =20% were suggested. Using the above formula, the student performances are calculated, and shown in Fig. 2. It is found that, due to personal level contact the performance of the C-averaged students in the year 2002 have increased from 57.1 to 75.4, which means a 32 percent increase in their performance. Similarly, for the year 2003, the performance of the C-averaged students increased from 60.1 to 73, a 21.5 percent increase. Although, for the A-averaged students, there was only 2.2 percent increase. As the overall learning performance has been linked to the ABET criteria 3(a-k) and additional ME Program criteria (l-s), so the increase in performance due to personal contact, in turn demonstrates the percentage increase in satisfying the ABET plus criteria, which is the desired goal. Also from Fig. 2, we find that the C-averaged students were getting 57.1 and 60.1 before personal contact, in the years 2002 and 2003, which means failing grades and more students dropping from program. But after personal contact, these have improved to 75.4 and 73, respectively. This improves student retention and will help to increase the percentage of minority black engineers in future.



(a). Attendance



(b) Homework and Quiz



(c) Exams

Fig. 1. Learning Outcome for A and C Averaged Students during 2002 and 2003, both Before and After Faculty-Student Personal Contact

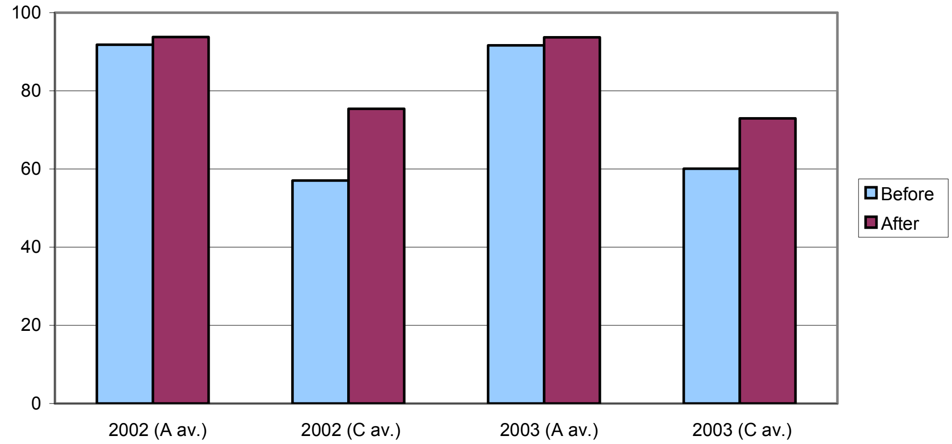


Fig. 2. Student Overall Learning Performance for A and C Averaged Students during 2002 and 2003, both Before and After Faculty-Student Personal Contact

4. Conclusion

This paper describes that the assessment tools used for measuring the outcomes of the Mechanical Engineering program at Alabama A&M University are based on the ABET requirements and some additional requirements of ASME. The outcome of a particular course, Thermodynamics is studied. It is found that personal level contact between faculty and student, especially with those who miss class frequently, can significantly improve the attendance, homework and exam grading, and consequently the overall performance. This shows a positive direction for improving the outcome of some minority engineering students, and helps to satisfy the ABET criteria. Personal contact would also improve student retention and will help to increase the percentage of minority black engineers in future.

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