AC 2009-654: TRANSFORMING A COURSE ON AUTOMOTIVE EMISSIONS CONTROL THROUGH THE USE OF ASSESSMENT TOOLS

Janet Braun, Western Washington University

Transforming a Course on Automotive Emissions Control Through the Use of Assessment Tools

Abstract

Students involved with the Vehicle Research Institute at Western Washington University choose between two degree paths, either a Bachelor of Science in Industrial Technology – Vehicle Design or a combined Bachelor of Science in Plastics Engineering Technology/Vehicle Engineering Technology (PETVET). Students in both programs take Advanced Emission Control as a requirement for graduation. Prior to 2008, the content of this course focused mainly on the history of government regulations imposing emissions controls on vehicles, the effect of automotive emissions on our environment and health and the strategies employed starting in the 1960s to reduce the amount of harmful emissions from vehicles.

In an attempt to modify the course content to provide students with an understanding of the contemporary issues facing automotive emission control, a hybrid approach was employed. The approach was hybrid in the sense that much of the original historical content was included at the beginning of the term while the content during the later part of the term was shifted towards understanding the current technical issues that must be overcome to reduce automotive emissions to near-zero levels and the opposing goals that must be balanced to do so. Various tools were employed beginning in term 1 and continuing when the course was taught a second time, term 2, to assess the level of student interest in the topic of emissions control, demonstrated student learning, as well as the teaching effectiveness of the faculty. This paper chronicles those methods and how they were applied to systematically transform this course.

Pre-course tests were administered on the first day of class in each term. The content of the pre-course test during the first term was skewed heavily towards the historical content of the course as it had been presented previously. Student surveys were conducted at the end of the first term to determine those topics and activities the students found useful and those they did not. The survey also presented some topics which were not covered during the first term to determine if they should be included in the subsequent term. The result of this survey, in addition to verbal discussions with the students, prompted modification of the course content for the second term, as well as the content of the pre-course test. Overall, students requested much less detail on the historical aspects of the emissions challenge and expressed a desire to develop not only an understanding of current production vehicle emission control strategies, but also of future innovations in this field.

Corresponding post-course tests were then administered at the end of the terms to determine the extent of student learning. Anonymous teaching evaluation surveys were also completed by the students to determine the teaching effectiveness of the faculty. These tools, along with engaging in open communication with the students, have helped transform Advanced Emission Control into a contemporary study on the challenge of further reducing automotive emissions while balancing opposing goals, a typical engineering trial.

Introduction

Western Washington University's Vehicle Research Institute (VRI) strives to offer the best total car design curriculum in the world. The VRI program offers two Bachelor of Science degrees, either in Industrial Technology – Vehicle Design or in Plastics Engineering Technology/Vehicle Engineering Technology (PETVET), and a post-baccalaureate certificate in vehicle design. All students in the program take Advanced Emission Control as a requirement for graduation. Prior to 2008, the content of this course focused mainly on the history of government regulations imposing emissions controls on vehicles, the effect of automotive emissions on our environment and health, and the strategies employed starting in the 1960s to reduce the amount of harmful emissions from vehicles.

In order to successfully assume responsibility for this class for the first time and to drive continuous improvement in subsequent terms, a structured approach was taken to gain an understanding of the usefulness of the current content and the desired future direction of the class. Environmental concerns are at the forefront of society today so the topic of automotive emissions is not only contemporary, but also controversial and perhaps more important now than ever before. VRI students are certainly all passionate about vehicles, but many are also passionate about protecting the environment. Soliciting their input in improving this course was the most obvious place to start, and this was undertaken starting in term 1 and continued when the course was taught the second time, term 2. Assessing their performance with respect to specific learning objectives also supports the continuous improvement required by the Accreditation Board for Engineering and Technology (ABET).

In term 1, much of the original historical content was included at the beginning of the term while the content during the later part of the term was shifted towards understanding the current technical issues that must be overcome to reduce automotive emissions to near-zero levels and the opposing goals that must be balanced to do so. Various tools were employed in term 1 to assess the level of student interest in the topics of emissions control, demonstrated student learning, as well as the teaching effectiveness of the faculty, in order to provide direction in further modifying the course for term 2. These tools were used again in term 2 for further course improvement. This paper chronicles those methods: assessment, surveys, evaluations, and informal dialog, and how they were applied to systematically improve this course.

Assessment

Pre-course tests were administered on the first day of class in each term to not only assess students' knowledge coming into the class, but also to understand any misconceptions they might be bringing with them. The content of the pre-course test during the term 1 was skewed heavily towards the historical content of the text which had been in use for this course for some time. This test consisted of 15 multiple choice questions. For term 2, a new textbook was adopted focusing on the state-of-the-art emissions control and current research in the area of near-zero emissions, so the questions of the test were changed to reflect this new content and expanded to 18 multiple choice questions. The main course learning objectives did not change, however, and Table 1 addresses how the test questions aligned with these objectives for each term.

Corresponding post-course tests were then administered at the end of the terms to determine if the course learning objectives were being met. Assessment such as this is an important responsibility of the faculty member in the continuous improvement process[1].

Learning Objective	Term 1	Term 2	Description of Changes
Understand the emissions of internal combustion engines and how they are produced	4	7	Term 2 placed much more emphasis on specific engine operating conditions that continue to produce unwanted emissions.
Understand the federal, state and international regulations affecting allowable emissions from internal combustion engines	3	0	Term 1 content covered the chronological order of the increasingly stringent emission standards since the original Clean Air Act of 1963. Term 2 focused on the most recently mandated emission regulations and those scheduled to take affect within the next five years.
Understand various emission control strategies employed on internal combustion engines	7	11	Term 1 content included a historical view of emission control strategies starting in the 1960s, including strategies that are now obsolete. Term 2 focused on the more recent development of strategies still in use and the strategies being developed for the future.
Other	1	0	Term 1 included a question about naturally occurring Volatile Organic Compounds, which is unrelated to the emissions of internal combustion engines and was therefore omitted in term 2.
Total Number of Questions	15	18	

Table 1. Comparison of the number of questions pertaining to the course learning objectives and a description of changes between terms.

In both terms, students exhibited improvement in the number of correct responses on the post-course test compared to the pre-course test. Term 1 students improved from an average of 46% correct to 69% correct, and term 2 students improved from an average of only 31% correct to 67% correct. Comparing term 1 and term 2 pre-test scores (46% and 31%, respectively), a noteworthy difference exists between the terms. This difference is attributed to the fact that “I don’t know” was added as a response on each question for term 2, but was not available as a response for term 1, reducing the likelihood that students would guess correctly when forced to select either a correct or incorrect response. The average number of “I don’t know” responses reduced from 7.2 on the pre-course test to 0.5 on the post-course test for term 2. The average number of incorrect responses, however, was nearly the same suggesting that the “I don’t know” responses at the beginning of the term were converted to correct responses at the end of the term.

An examination of the responses by question yielded some interesting observations. As Verma and Crossman point out, a low score on a course objective “raises a red flag”, prompting faculty to seek out the cause of the problem.[1] In this case, most of the incorrect responses were distributed among five questions, with the majority of students getting each of these incorrect and in one case, every student selecting an incorrect response. A compilation of the pre-course and post-course test responses can be found in Charts 1 and 2.

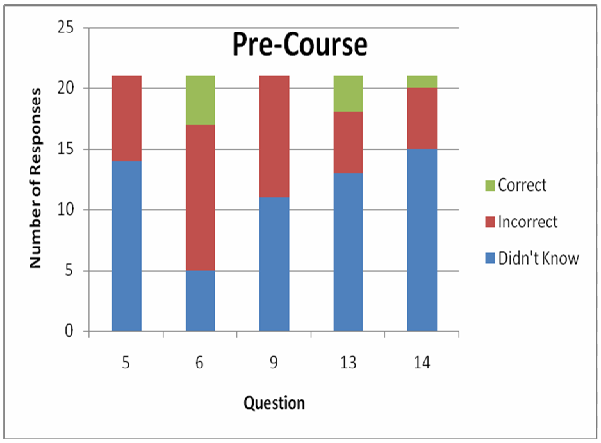

Chart 1. Pre-course test responses.

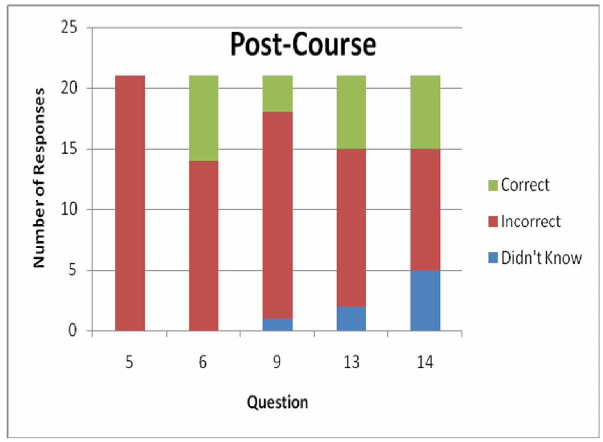

Chart 2. Post-course test responses.

The shift from “I don’t know” to incorrect responses is believed to be evidence in support of Wankat’s statement that “learning is always based on what the students know and believe. Thus, the students’ preconceptions are very important for learning.” Wankat goes on to point out that preconceptions must be forcefully corrected to change the knowledge structure to include the correct facts.[2] Question 5, which every student got incorrect on the post-course test, pertains to a relationship that seems counter-intuitive at first, but which makes sense after understanding the interaction of the variables. Wankat describes what likely happens when students are faced with correct facts that aren’t part of their knowledge structure, saying “the easiest things to do are discard the facts, memorize the facts as unconnected items, or change the facts so that they will fit”.[2] That the students failed to correct their knowledge structure is most likely because this fact was not compelling enough for them to make the change based on how it was presented to them and will be an area for improving teaching effectiveness in the future.

Surveys

As the goal of this research was to improve the course content, a review of the options for collecting information to support this activity was conducted. Olds, Moskal and Miller provide a guide to a variety of methods typically and not so typically used in assessments of engineering education. For the information desired, which is purely descriptive in nature, surveys emerged as the most efficient method and the most popular, perhaps because if their efficiency. The authors debate the merit of open-ended vs. selected-response questions but ultimately suggest that utilizing both types will maximize the information gained from the survey tool[3].

A different survey was created for each term, although the format was identical, and conducted at the end of the term. The surveys included selected-response questions regarding the topics covered that term and a host of other topics which were not specifically covered but which would fit under the umbrella of an automotive emissions control course. Students were asked to circle yes or no to whether each of these topics should be included in this course in the future. Similarly, students were polled about the lab activities and about the grading structure. Students were then asked open-ended questions on ideas to improve the class, other topics or activities to include, and for any other additional comments.

The results of the term 1 survey prompted a much needed modernization of the course content for the second term, as well as the content of the pre-course test. Overall, term 1 students requested much less of the historical content of the course which focused on some emission control technologies which are now obsolete. Carburetor developments, as an example, were once important in reducing emissions, but eventually became obsolete as regulations became more stringent, rendering the carburetor inadequate to control emissions at the required levels. Students very astutely expressed a desire to instead more deeply explore the technologies currently in use on production vehicles to control emissions, and to learn about innovations in this field which may be employed on future vehicles. The survey in term 1 also revealed that the lab activities were not found to be beneficial.

Term 2 surveys indicated that every topic included in the course the second term was worthwhile and meaningful to the students. Students also suggested that the additional topics be covered as well, at least briefly. The lab activities were much more beneficial to the students in term 2; however, more improvement is needed in this area.

Teaching Evaluations

Anonymous teaching evaluation surveys were also completed by the students to determine the teaching effectiveness of the faculty. These evaluations are a university standard and required by contract for the review of tenure and promotion of all faculty. As Wankat & Oreovicz point out, the questions on these types of evaluations are not generally useful in improving course content[4]. In addition to the standard questions, students are given the opportunity to anonymously write comments regarding the teaching effectiveness and the course content. Review of these comment sheets did not reveal anything further to what the students had already provided in the surveys.

Informal Dialog

In covering the methods for doing student evaluations, Wankat & Oreovicz condone the use of informal evaluation procedures when the purpose of the evaluation is course improvement and suggest that "chatting with students informally during the semester often points out what is or is not working."[4] As in industry when one leads a group of employees, open communication is imperative and creating an environment conducive to communication is paramount in a leader's responsibilities. Likewise, a classroom environment that encourages and fosters mature communication can provide real-time feedback to the professor, allowing for immediate changes or improvements for the future.

As stated earlier, soliciting input from the students was an obvious place to start in gathering information to improve this course. Term 1 students were aware that their professor was newly assigned responsibility for this course and as a result were very forthcoming with suggestions for improvement. The verbal discussions with these students provided support and clarity for the survey responses, which together were the basis for the improvements made for term 2. The informal dialog from term 2 will in turn be used with the survey responses from term 2 to make further improvements for the future.

Next Steps

Assessment, teaching evaluations and surveys will continue to be used in the future as feedback mechanisms in the continuous improvement cycle. In addition, now that course content is much closer to where it needs to be, the course learning objectives will be refined and possibly expanded. As this occurs, the method of assessment will evolve to ensure teaching methods are helping students attain these learning objectives. These steps are necessary for this course, as well as others in this Engineering Technology program, to achieve and maintain ABET accreditation.

Summary

Pre- and post-course tests, student surveys, teaching evaluations and informal dialog with students were all employed to provide direction in improving this course on automotive emission control. Of these tools, the student surveys and the informal dialog with students provided the information necessary to improve the course content and the methods of teaching. The pre- and post-course tests were useful in discovering students' preconceptions and in their attainment of the course learning objectives, identifying areas where improvement is needed in helping the students correct their knowledge base. Teaching evaluations were the least helpful because even though required by contract at this university, they are designed for a different purpose and not ideally suited to gathering the correct information for course improvement. Each of these tools will be used again in future terms and will evolve as learning objectives are refined to continue the cycle of improvement.

Bibliographic Information

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