December 1981
Final Report

DOT HS-806 277

US Department of Transportation
National Highway Traffic Safety Administration

National Energy Efficient Driving System (NEEDS) Volume II—

A. J. McKnight
M. Goldsmith
D. Shinar

National Public Services Research Institute
123 North Pitt Street
Alexandria, Virginia 22314

Contract No. DOT-HS-7-01775
Contract Amount $224,678

Technical Report Documentation Page

1. Report No. DOT-HS-806 277	2. Government Accession No.	3. Recipient's Catalog No.

4. Title and Subtitle
National Energy Efficient Driving System (NEEDS): Final Report. Vol. II, Driver Education Program

5. Report Date
December 15, 1981

6. Performing Organization Code

7. Author(s)
McKnight, A. J.; Goldsmith, M.; and Shinar, D.

8. Performing Organization Report No.

9. Performing Organization Name and Address
National Public Services Research Institute
123 North Pitt Street
Alexandria, VA 22314

10. Work Unit No. (TRAIS)

11. Contract or Grant No.
DOT-HS-7-01775

12. Sponsoring Agency Name and Address
National Highway Traffic Safety Administration
400 Seventh Street, S.W.
Washington, D. C. 20590

13. Type of Report and Period Covered
Final Report
9/77 - 12/81

14. Sponsoring Agency Code

15. Supplementary Notes Portions of the work reported were performed by the Texas Transportation Institute, Texas A & M University. Dr. John Eberhard served as the NHTSA Contract Technical Manager.

16. Abstract Studies were conducted to identify young driver deficiencies in knowledge, attitude, and performance with respect to fuel-efficiency. Five different programs of classroom-only and classroom/in-car instruction were administered experimentally to high school driver ed. students. Comparison of pre- and post-knowledge scores within and across groups showed that classroom instruction alone improved knowledge. In-car training did not provide additional improvement. Post-training performance scores of instruction groups were compared with those of a control group. Results disclosed no significant differences between any groups receiving instruction and the control group. In a second experiment, two revised programs of classroom-only and classroom/in-car instruction were administered to another sample of driver ed. students. Comparison of pre and post knowledge and attitude scores showed significant improvements in knowledge and smaller improvements in attitudes among groups receiving instruction. In-car training was no more successful than classroom instruction alone in improving knowledge or attitudes. Performance measures indicated no significant differences within or across groups. Neither program was able to improve performance. In a final study, the relationship between acceleration rate and fuel economy was investigated using six automobiles of different weights, all with automatic transmissions. The cars were instrumented to permit measurement of fuel consumption between stops. Each was driven over the same test course and accelerated 30 times to 30 mph at each of three acceleration levels: low (.1 g), moderate (.2 g), and brisk (.3 g). Results indicated that in general a moderate acceleration is optimum. Some lighter vehicles were slightly more efficient at low accelerations, while some heavier vehicles were slightly more efficient at brisk accelerations.

17. Key Words
Fuel-efficient driving; energy conservation; energy-efficient driving; driver education; young drivers; in-car training; BTW training.

18. Distribution Statement
Document available to the U.S. public through the National Technical, Information Service, Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price

Form DOT F 1700.7 (8-72)

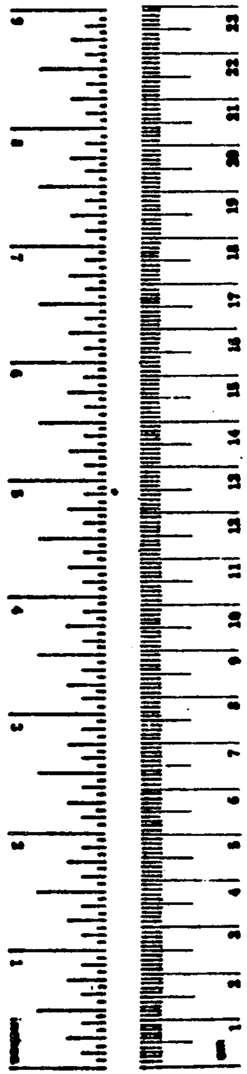
Reproduction of completed page authorized

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

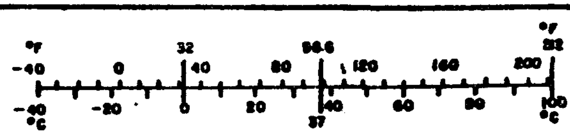
Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



PREFACE

This volume describes a series of studies carried out to determine the most effective approaches to the introduction of fuel-efficient driving through driver education courses. The work was performed by the National Public Services Research Institute under contract to the National Highway Traffic Safety Administration (Contract No. DOT-HS-7-01775).

The work described in this volume was part of a broad investigation of voluntary fuel consumption that constituted the National Energy Efficient Driving System (NEEDS) project. The following additional volumes describe other activities undertaken as a part of the NEEDS effort:

> National Energy Efficient Driving System, Volume I: Survey of Requirements. This volume describes a broad range of energy-efficient driving behaviors, the information needed to influence those behaviors, the target audience to be addressed, the materials needed to reach the target audiences, and the delivery systems capable of disseminating the materials.

> National Energy Efficient Driving System, Volume III: Home Vehicle Use Study. This volume describes a study undertaken to improve the efficiency of home vehicle use through feedback of information on fuel consumption.

Dr. A. James McKnight served as the NPSRI Principal Investigator during the project phase reported in this volume. Mr. Morris Goldsmith served as Project Administrator, supervising the preparation of training materials, the administration of studies, and the analysis of data. Dr. David Shinar of Ben Gurion University of the Negev performed data analyses and helped to prepare this volume.

The authors are indebted to:

> Dr. John Eberhard, NHTSA Contract Technical Manager, for his advice and support throughout the NEEDS project.

> Mr. Michael Sadof, NPSRI Data Processing Manager, for carrying out the statistical analyses contained in this volume.

> Dr. R. Don Williams, and others on the staff of the Texas Transportation Institute, for collecting much of the data involved in identifying student skills efficiency and the effect of vehicle acceleration rate upon fuel consumption.

> Ms. Ruth Freitas, Ms. Patricia Goll, and Mr. Eugene Fasnacht for preparation of materials used in the study and typing of this volume.

> The driver education teachers at Edgewood High School, Edgewood, Maryland, and Friendly High School, Oxon Hill, Maryland, for administering the driver education programs and certain of the evaluation measures.

TABLE OF CONTENTS

Table of Contents (continued)

Page

INTRODUCTION

BACKGROUND

The objective of the National Energy Efficient Driving System (NEEDS) is to foster fuel-efficient transportation practices. The first phase of the project identified a broad array of practices, along with information required for their adoption; the agencies through which that information might be delivered; and the materials and services needed to support the delivery process. Data gathered in that phase are summarized in Volume I of the final report.*

The research reviewed in Volume I indicated that drivers trained in energy-efficient driving techniques were capable of obtaining a reduction of 10 to 15% in fuel consumption and that it should be possible to motivate drivers to use energy-efficient driving techniques since there is little or no sacrifice involved: It is just as fast, economical, and easy to drive efficiently as inefficiently. Therefore, the prospects of increasing fuel-efficient operation appeared good, provided the appropriate skills could be taught. One of the needs identified early in the project was for driver education programs to impart fuel-efficient operating techniques to high school students. This volume discusses four studies that were conducted in response to that need.

DRIVER EDUCATION PROGRAMS AND FUEL-EFFICIENT DRIVING

Within the high school curriculum, the driver education course is probably the most suitable medium through which to offer fuel-efficient driving programs. Driver education is the only delivery system that reaches sizable numbers of drivers--over 3 million each year. According to the 1978 Driver Education Status Report, published by the National Safety Council, driver education programs are available in 81 percent of public, private and parochial schools, and 81 percent of eligible students receive some form of driving instruction. Although the percentage of schools offering such instruction appears to be declining slightly, the percentage of students receiving the instruction has increased. Therefore, programs integrated into the driver education course can be assured of reaching large numbers of drivers.

High school driver education students represent an attractive target for energy-efficient driving programs--particularly those that focus on operating techniques--for the following reasons:

---

* National Energy Efficient Driving System: Volume I, Survey of Requirements. National Public Services Research Institute, December 1981.

- The availability of vehicles allows the uniform behind-the-wheel training needed to teach operating techniques.

- The length of driver education programs--generally 36 hours of actual instruction--permits the extensive training needed to instill long-term energy-efficient driving habits.

- Gains in fuel conservation practices that are achieved with high-school-age students can be extrapolated over an entire driving lifetime.

- Instruction and training in energy-efficient driving habits can be incorporated into existing programs, thus requiring no additional administrative expenses and possibly no additional training or instruction time.

TARGET BEHAVIORS

Four categories of driver behavior were identified as potential areas for realizing fuel savings. These are:

- Planning--Trip planning for reducing time on the road through proper route selection, trip consolidation, use of public transportation, ride sharing, and trip reductions.

- Operation--Operating the vehicle in a fuel-efficient manner, through better vehicle control habits and compliance with the national maximum speed limit.

- Selection--Selecting vehicles on the basis of fuel efficiency and exercising a prudent choice of options.

- Maintenance---Maintaining the vehicle according to the manufacturer's manual. This includes both owner maintenance and garage services.

Available data suggest that in each one of these categories the potential fuel savings can be as much as 10 to 15%, with the exception of Selection where the savings can be as much as 100% within a vehicle class. While the fuel savings that can be obtained in any one category may not be enough to motivate change, the total certainly is.

RESEARCH QUESTIONS

Many high school driver education programs now include some fuel economy training. However, the effectiveness of that training has not been sufficiently evaluated. Where savings have been demonstrated, it is not known whether they can be generalized to situations beyond those that are observed when the drivers are aware of that observation. Moreover, if such savings can be generalized to unobserved situations, there remains the question of how long the effects of training will endure.

Other critical questions had to be answered before any fuel-efficient driving programs for high school students could be developed:

- <u>What are the deficiencies of the audience to be addressed by the programs?</u>

  Driver deficiencies that can hamper fuel-efficient driving include lack of knowledge, inappropriate attitudes, inadequate skills, and poor driving habits. The nature and magnitude of deficiencies characteristic of high school students had to be determined before there could be any attempt to develop training programs that addressed them. For example, a program providing incentives to driving fuel-efficiently would be useless if the major deficiency were ignorance of fuel-efficient driving skills. On the other hand, use of incentives would be appropriate if the major problem were poor attitudes.

- <u>How much and what kind of behind-the-wheel instruction is necessary?</u>

  Behind-the-wheel instruction is costly because of expenses involved in obtaining, maintaining, and operating the vehicles, and in providing the high teacher/student ratio needed. The minimum amount and kind of in-car instruction needed had to be determined.

- <u>What is the role of in-car aids?</u>

  Many of the programs that have been cited for achieving fuel savings used in-car aids and displays such as vacuum gauges and fuel flow meters. The need to use them in training may be an obstacle to widespread program implementation. While these devices themselves are not extremely expensive, their purchase and installation adds significantly to the cost of in-car instruction. Moreover, if these aids turned out to be necessary for maintaining the skills acquired through their use, then the need for students to obtain them once formal training was completed could dilute the effects of the program.

- <u>How are energy-efficient techniques to be integrated into driver education?</u>

  Given its defensive posture these days, driver education is in no position to expand in order to incorporate energy-efficient driving instruction. Therefore, the prospects for widespread implementation depend greatly on how easily energy-efficient driving instruction can be integrated into current driver education programs.

The research program designed to answer these questions consisted of four studies. The purpose of the first study was to identify knowledge, attitude, and skill deficiencies of young drivers relative to fuel conservation, as well as to obtain an estimate of their overall driving performance in terms of fuel efficiency. The purpose of the second study was to investigate in-car training methods. The third study focused on instructional methods, and the last was a study of vehicle acceleration rates and their relationship to fuel economy. The remainder of this volume is devoted to the detailed description of each of these studies.

STUDY OF DRIVER DEFICIENCIES

This section describes an analysis of young drivers undertaken to determine the nature and magnitude of their deficiencies relative to fuel-efficient driving.

NATURE OF DEFICIENCIES STUDIES

To identify driver deficiencies, two populations were sampled: inexperienced and experienced drivers. Sampling from these two populations permitted the deficiencies of each to be compared. Deficiencies that characterized both populations would point to failure of driver education courses to develop the relevant knowledges, attitudes, or skills. Where only the inexperienced drivers were deficient, it could be assumed that deficiencies had been overcome through additional driving experience, obviating the need to correct the deficiencies during driver education.

If the experienced drivers were found to be significantly more deficient than the novice drivers, then the problem could be assumed to be one of deterioration of knowledge, attitudes, or good driving habits. In that case, a program would be needed that could produce more enduring effects.

METHODS

The following is a description of the methods used to identify driver deficiencies in the areas of knowledge, attitudes, skills and overall driving performance.

Measurement of Knowledge

A knowledge test containing 34 multiple-choice, triple-option questions particularly relevant to the four areas of Planning, Operation, Selection and Maintenance was administered to a sample of 4,279 high school students. The sample consisted of three groups: 1,595 students who had not yet had a driver education course, 2,275 students who had just completed the course, and 427 students who had had one or more years of licensed driving experience. It was assumed that the large sample sizes in each category would act to overcome the effects of any specific driver education programs in which the students had participated.

Measurement of Attitudes

An attitude questionnaire was administered to 75 high school students currently enrolled in driver education. Each of the items was associated with one of the four areas relevant to fuel-efficient driving: Planning, Operation, Selection, and Maintenance.

Measurement of Skills

The measurement of driver skills was performed using NHTSA's Driver Performance Measurement and Analysis System (DPMAS) installed in a 1978 Chevrolet Impala with automatic transmission. The sample consisted of a group of ten novice drivers and a group of ten experienced drivers. The novice drivers were all students who were enrolled in the driver education program at A & M Consolidated High School (College Station, Texas) and who had completed all portions of the curriculum and received their instructional permits, but had not yet taken the State road test. The experienced drivers were randomly selected from the at-large driving population and were between the ages of 22 and 40.

Driving skills were tested by having each of the drivers drive a one-mile off-street closed-loop course four times, twice in each direction. The course consisted of gentle and sharp curves, 90-degree intersections, and one location where drivers had to stop at a stop sign. Driving was controlled entirely by signs in order to prevent performance from being influenced by instruction from the investigator riding in the car. The performances studied included acceleration, cruising, and deceleration from speeds of approximately 45 mph and 30 mph.

The measurement, display, and recording capabilities of the DPMAS were described in a NHTSA report (Klein et al., 1976). For the purpose of this study, vehicle speed, longitudinal acceleration, and instantaneous and accumulated fuel consumption were displayed in real-time and recorded, split-imaged with the moving scene ahead of the driver as recorded by another video camera. This allowed all of the instrument readings to be correlated with the external environment.

Measurement of Overall Performance

Overall performance was defined as the integration of knowledge, skills, and attitude into normal driving practices. Measures of overall performance were obtained by videotaping the performance of the same 20 subjects used for measurement of skills on a five-mile in-traffic route consisting of urban, suburban, and rural driving. It should be noted that the drivers were aware that the fuel efficiency aspects of their driving were being recorded. This awareness was reinforced by the presence of the car of an investigator who manually recorded certain behaviors. Fuel conservation was evaluated by observing the extent to which the drivers maximized the use of the momentum they achieved while driving through traffic. Conservation of momentum is possible:

- o At Traffic Controls--by coasting to a stop sign or a stop light rather than accelerating and then braking.
- o When Faced with Path Obstructions--by either changing lanes while maintaining the same speed or coasting until the path is clear (e.g., timing a left turn to coincide with a gap in oncoming traffic).
- o On Upgrades--by maintaining sufficient speed rather than letting the speed drop and then reaccelerating.

RESULTS

The results obtained from measurement of knowledge, attitude, skills, and overall performance are discussed below.

Knowledge

The number of knowledge test items answered correctly was tallied separately for each of the three groups of drivers by content area. The average percentages of correct responses are presented in Table 1.

TABLE 1

PERCENTAGE OF CORRECT RESPONSES BY CONTENT AREA AND GROUP

Content Area	# of Items	Group Pre D.Ed.	 Post D.Ed.	 Licensed
Operation	18	33%	38%	40%
Selection	11	36%	37%	39%
Use	4	38%	40%	45%
Maintenance	1	45%	45%	45%
Total	34	35%	38%	40%

The results are striking in several ways. First, knowledge in all four areas is relatively poor for all three groups. It should be pointed out that the percentages presented in the table would be lower if they were to be corrected for chance. Since all the items were triple-option, multiple-choice questions, chance selection of each item would be 33%. Therefore, the highest percentages displayed in the table (those for the single maintenance item) are only 18% above chance. Tests of proportions conducted separately for each of the driver groups and for each of the content areas and a test conducted on the total table revealed no significant differences among the levels of knowledge and groups of respondents.

An item analysis conducted on each of the 34 knowledge items revealed no significant differences among the groups with the exception of one item on which one group performed slightly better than the other two. After correction for chance and given the nonsignificant differences in the other items, that too can be considered chance variation. In toto, the results indicate that the knowledge of most young people about fuel-economy is relatively meager and neither present driver education programs nor accumulated driving experience increases that knowledge.

Attitudes

The four options available on each of the attitude items were coded on an ordinal scale from "most fuel-efficient" through "more fuel-efficient" and "less fuel-efficient" to "least fuel-efficient." The number of students selecting each response was computed and combined for all items in each of the content areas. The percentage of students endorsing responses in each category for each of the content areas is presented in Table 2.

TABLE 2

PERCENTAGE OF STUDENTS SELECTING EACH ATTITUDE RESPONSE CATEGORY BY CONTENT AREA

	Content Area			
Response Category	Operation	Maintenance	Selection	Use
Most Fuel-Efficient	62%	74%	18%	38%
More Fuel-Efficient	35%	23%	37%	51%
Less Fuel-Efficient	3%	3%	28%	7%
Least Fuel-Efficient	0%	0%	17%	4%
	100%	100%	100%	100%

As can be seen from the table, in the areas of Operation and Maintenance by far the most frequent responses were "most" or "more fuel efficient." In these two areas only three percent of the students endorsed an attitude that can be considered fuel-inefficient. When it comes to Use, the picture is not quite as favorable, although the overwhelming majority of students surveyed chose a response consistent with fuel-efficient use.

Only in the area of Selection does there appear to be a normal distribution of responses across the whole range of attitude levels. Apparently this is one area in which people are willing to sacrifice fuel efficiency for other considerations. In the light of the significant fuel savings that can be achieved in this particular area, these results suggested that one of the concerns of any educational program should be attitude change regarding vehicle selection considerations. In the other three areas, where attitudes are already positive, the task appeared to be simply to inform students how to drive, maintain, and use their cars in a manner consonant with their attitudes.

Skills

In the closed-loop course, the vehicle control task that most affected fuel consumption was acceleration after complete stops and when leaving curves. Results were analyzed to determine the relationship between fuel efficiency and rates of acceleration and to see whether the fuel consumption of the novice and experienced drivers differed.

It should be mentioned that the relationship discussed here between acceleration and fuel consumption (in terms of miles per gallon) is relevant only to vehicles with automatic transmissions. For cars with manual transmissions, the overriding determinant of fuel efficiency is the gear shifting technique used by the driver rather than the rate of acceleration.

The total amount of fuel consumed by each of the 20 drivers was recorded. The mean fuel consumption (in gallons) and standard deviation around that mean are presented separately for the novice and experienced drivers in Table 3.

TABLE 3

FUEL CONSUMPTION IN GALLONS BY NOVICES AND EXPERIENCED DRIVERS OVER A CLOSED COURSE

	Novices	Experienced
Mean	.363	.361
S.D.	.040	.016
N.	10	10

Since there is no absolute criterion for "fuel-efficient" driving, it is impossible to determine whether the fuel consumption was high or low. What can be stated on the basis of these results is that there is no difference between the two groups in terms of mean fuel consumption. But there is a large difference between the two in terms of the interdriver variability ($F = 6.25$, $p<.01$). Variability among the novices was almost three times as high as among the licensed drivers. Among the novices, the least efficient drivers consumed 70% more fuel than the most efficient. Among the experienced drivers, the least efficient consumed only 17% more fuel than the most efficient.

These data suggest that one of the effects of experience is to wash out initial individual differences and make behavior uniform and systematic. Although the analysis was cross-sectional rather than longitudinal, it is consistent with findings in other areas of driver behavior indicating that individual differences are large among novice drivers and small among experienced drivers (e.g., eye movement behavior, Mourant and Rockwell, 1970).

Since the primary source of the variance in fuel efficiency was attributed to acceleration rates, the relationship between the two was studied directly. This was done by computing for each driver the average acceleration rate and the total mpg achieved during acceleration when pulling out from the stop sign. Since each driver made four runs over the course, 80 data points were obtained. These are presented in the scatter plot in Figure 1. Although there appears to be quite a large amount of scatter, the Pearson correlation between the two variables was 0.45, higher mpg being associated with greater accelerations. In particular, the scatter plot indicates that high mpg is associated with average accelerations exceeding 0.11 g.

Figure 1 also shows that all of the accelerations were relatively low, none exceeding 0.15 g. Low acceleration may be indicative of a belief that fast accelerations reduce fuel economy. The study conducted to explore this issue is discussed later in this volume.

Overall Performance

The total fuel consumed by each driver over the five-mile route was calculated. The mean and standard deviation of fuel consumption for each of the two groups are presented in Table 4.

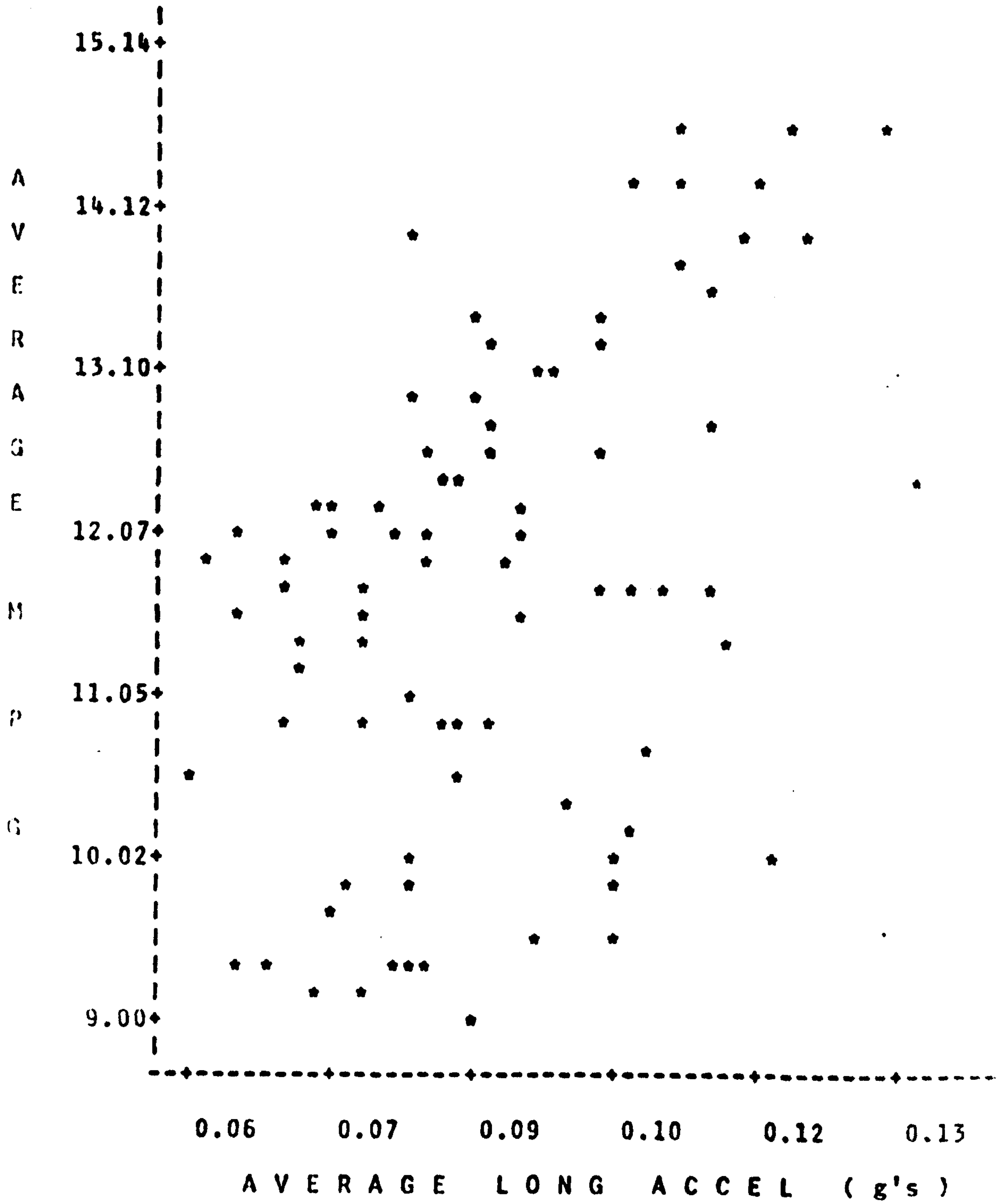
TABLE 4

FUEL CONSUMPTION IN GALLONS BY NOVICES AND EXPERIENCED DRIVERS OVER A STREET ROUTE

	Novices	Experienced
Mean	1.71	1.68
S.D.	.089	.110
N.	10	10

FIGURE 1

SCATTER PLOT OF THE RELATIONSHIP BETWEEN AVERAGE ACCELERATION AND MPG



As can be seen from the table, there were no significant differences between the two groups in mean or variance. A comparison of the means obtained in on-street and closed-course driving is meaningless because of the differing distances. However, a comparison of variability around mean consumption is a meaningful one. The standard deviations shown in Table 4 when compared with those in Table 3 reflect increased variability for both novice and experienced drivers. However, there is a much greater increase for the latter.

Among the novices, the least efficiert driver consumed 21% more fuel than the most efficient driver. Among the experienced drivers, the least efficient consumed 25% more fuel than the most efficient. Comparisons of the variance and range of differences of the two groups of drivers on the two driving courses, indicates that, in the absence of constraints imposed by other traffic, individual differences come into play and the novice population manifests a larger range of fuel-efficiency levels. In contrast, on-street driving imposes severe constraints on both groups of drivers and the range of fuel-efficiency levels among drivers in each group becomes smaller, reflecting the effect of the traffic environment more than the effect of the individual differences. It is probable that the remaining range of variations is due to momentary fluctuations in the traffic that are beyond experimental control. These results also suggest that the real-world traffic environment may greatly influence the level of fuel-efficiency and greatly reduce individual differences.

To determine whether the individual differences observed on the close-loop course were carried over to on-street driving, the two measures of fuel consumption were correlated, yielding a Pearson correlation of .54. This means that approximately 25% of the variations among drivers in on- street driving may be accounted for by factors that are measured in an off-street course.

The data obtained on conservation of momentum in response to traffic controls, path obstructions, and upgrades were almost entirely qualitative. Any attempt to obtain quantitative data would have been extremely complicated and would have had to assume the homogeneity of various confounding variables, an assumption that probably would not have been warranted. The observations that were made revealed that the majority of both novices and experienced drivers were totally inattentive to conservation of momentum. The drivers typically accelerated at the wrong times, often at a point where it was obvious that they would shortly have to brake.

CONCLUSIONS

The following conclusions are drawn from the results in each of the areas investigated:

1. Knowledge--In the areas pertaining to fuel conservation, driver knowledge is very meager. Almost total ignorance was demonstrated in the four areas of Operation, Selection, Planning, and Maintenance. This was true for all three groups of drivers, suggesting that neither the present programs of driver education nor the cumulative effects of driving experience (once a license has been obtained) provide this knowledge.

2. Attitudes--Current attitudes toward fuel conservation appear to be highly favorable in the areas of Operation, Maintenance, and Planning. On the other hand, Selection is apparently governed by other motives that may cause drivers to choose vehicles that are relatively fuel inefficient. Because the attitude survey was conducted only among students enrolled in a driver education program, they probably do not reflect the attitudes of the public at large. A trend toward the purchase of smaller cars has characterized vehicle selection since 1978 and has been the primary reason for reduction in fuel consumption by personal vehicles since that time.

3. Skills--In the absence of any constraints imposed by other traffic, there appears to be no difference between novice and experienced drivers in their ability to accelerate in a fuel-efficient manner. Furthermore, for the single vehicle used in the study, it appears that higher acceleration is associated with greater fuel efficiency. Most drivers tended to accelerate rather slowly (accelerations averaging less than 0.1 g) and therefore achieved low mpg.

4. Overall Performance--There is a correlation between fuel efficiency on the closed course and fuel efficiency on the open road. However, additional requirements of on-street driving account for most of the variation among drivers. Qualitative assessements of driver ability to conserve momentum in negotiating obstructions, climbing up grades, and responding to traffic controls indicate that neither novice nor experienced drivers use fuel-efficient practices.

Summary

The results of the driver knowledge test, the attitude survey, the closed-course test of skills, and the on-street assessment of overall performance indicated that driver education and training in fuel economy would be appropriate at the high school level. In the light of the identified deficiencies in skills and overall performance and the generally favorable attitudes toward fuel conservation that were evidenced, it appeared that programs to teach and develop fuel-efficient driving skills would be most appropriate.

The absence of significant differences in performance between the novice and the experienced drivers, coupled with the poor performance levels obtained (where a criterion for good performance was available), suggested that fuel-efficient driving programs could be beneficial for both novice and experienced drivers.

Because of the different delivery mechanisms involved, different programs would be required to teach novice and experienced drivers. At the present time, novices appear the more promising target because of the ability to reach large numbers of the students through intensive programs of behind-the-wheel instruction already established in high schools. The remainder of this volume describes efforts to study factors believed to be important to the effectiveness of driver education programs in fostering fuel-efficient driving behavior.

EVALUATION OF IN-CAR TRAINING METHODS

INTRODUCTION

This section describes an evaluation of in-car training methods in current use. These involve both instrumented and instructor feedback.

Instrumented Feedback

Most of the fuel efficiency training programs reviewed and evaluated as part of the NEEDS project utilized a device that provided drivers with real-time feedback on their fuel efficiency. If such devices are to be used as part of a comprehensive training program, their costs may be a significant factor. Also, where the vehicles used for driver education are current models loaned by local dealers, the dealers are often reluctant to permit installation of such devices since it requires structural changes that, once the devices are removed, may lower resale value.

Instructor Feedback

The second type of feedback investigated in this study is that provided by instructors to the students as they drive. Feedback on both fuel- efficient and fuel-inefficient behaviors is provided. This is the type of feedback most often employed in driver education courses. Pointing out the fuel-efficient and -inefficient responses of drivers to traffic in roadway situations is considered helpful to both drivers and student observers.

Observer Feedback

In a variation on instructor feedback, feedback is sometimes provided by student observers who critique the drivers after their stint behind the wheel is over. Providing feedback after driving is based on the observation that drivers are generally too preoccupied during driving to absorb comments and instruction concerning fuel economy and that simultaneous feedback benefits only student observers. In addition, using student observers to provide feedback requires that they pay attention. Otherwise, they often ignore the driver and the instructor and thus learn nothing from the ride.

RESEARCH QUESTIONS

The first question to be answered was whether instrumented feedback provides any benefits beyond those offered by instructor or observer feedback. A second research question was whether there are benefits of in-car instruction not found in classroom instruction. It seemed possible that beginning drivers are so preoccupied by the basic requirements of driving that they cannot meet additional requirements to drive in a fuel-efficient manner. Thus, any in-car feedback on fuel-efficiency might simply constitute an information overload--at best useless and at worst detrimental to the learning process.

METHODS

The study consisted of a controlled experiment in which several groups of drivers were administered different instructional programs, following which their fuel-efficient driving performance was evaluated.

Sample

The study sample consisted of 144 students enrolled in driver education at Edgewood High School in Edgewood, Maryland. At the time the study was performed, they were nearing completion of both the classroom and in-car phases of instruction. The students were randomly assigned to six experimental groups. Prior to assignment, all students were given a paper-and-pencil knowledge test to determine equivalency among the groups.

Experimental Groups

Five of the six groups were given instruction in fuel-efficient driving. The sixth group served as a control. The six groups are described below:

Control--This group received neither classroom instruction nor in-car training on fuel-efficient driving techniques.

Classroom--This group received only a two-hour classroom lesson on fuel-efficiency. The first hour of instruction was devoted to fuel-efficient vehicle operation. The second hour covered vehicle selection and trip planning.

Instructor Feedback--Students in this group received the same two hours of classroom instruction as the Classroom group, plus simultaneous instructor feedback on fuel efficiency during their BTW driving lessons. The feedback pertained to each of the following driving tasks: acceleration, steady speed driving, driving with the flow of traffic, hill climbing, maintaining safe headway, conservation of momentum when approaching a stop, and avoiding unnecessary braking. The students were given a copy of a pamphlet on fuel-efficient driving before the first driving session so that they could familiarize themselves with the proper procedures for each of the tasks to which feedback would pertain.

Instructor/Instrument Feedback--This group received the same classroom instruction and instructor feedback as the Instructor Feedback group, but in addition received feedback from a vacuum gauge by means of a display mounted on the dashboard throughout their BTW driving. The display was a lamp that flashed red whenever a student drove fuel-inefficiently and green when he drove fuel-efficiently. In addition, the device emitted a tone whenever the engine vacuum dropped below a prescribed fuel-efficient level.

Observer Feedback--This group received the same classroom instruction as the previous groups, and in addition received feedback from students observers riding in the car, rather than from an instructor. The students were provided with the pamphlet on fuel-efficient operation and a checklist of correct and incorrect procedures. Feedback was given after driving.

Observer/Instrument Feedback--This group received the same classroom instruction and observer feedback as the Observer Feedback group and in addition received the same instrumented feedback provided to the Instructor/Instrument Feedback group.

Instruction provided to the six groups is summarized below:

Group	Classroom	Instructor Feedback	Observer Feedback	Instrument Feedback
Control	no	no	no	no
Classroom	yes	no	no	no
Instructor Feedback	yes	yes	no	no
Instructor/Instrument Feedback	yes	yes	no	yes
Observer Feedback	yes	no	yes	no
Observer/Instrument Feedback	yes	no	yes	yes

Materials and Equipment

Materials and equipment included classroom materials, an in-car checklist, and a vacuum gauge.

Classroom Materials

Fuel-efficient operating techniques were covered during the first hour of instruction. The materials used were:

- The DOE fuel-efficient driving film "Running on Empty."
- A pamphlet, "Routes to Fuel Economy," describing a broad range of methods for conserving fuel, including vehicle operation selection, maintenance, and trip planning.
- Slides showing scenes such as approaches to intersections, hill climbing, and moving traffic in various configurations. Most of the scenes were photographed from the driver's position. For each slide the students discussed what the driver's driving strategy should be to minimize fuel consumption.

While the study focused upon methods of teaching fuel-efficient operating techniques, the content of instruction also covered vehicle selection and trip planning. These additional subjects were taught in the next two hours of classroom instruction, using the following materials:

- A slide/cassette program entitled "The Short-Trip Fuel Penalty," demonstrating the inefficiency of short trips and describing methods of combining and consolidating trips.
- An exercise in which students were provided a set of short trip travel requirements and asked to plan the trips in a way that would minimize fuel consumption.
- A vehicle selection exercise in which students were provided descriptions of hypothetical family transportation needs, as well as a set of vehicle specifications, and required to match one with the other in order to fulfill the needs as fuel efficiently as possible.

Checklist

A checklist was used for the Observer Feedback and Observer/Instrument Feedback groups. It listed a number of driving tasks and the correct and incorrect responses to each with regard to fuel efficiency. The checklist (1) cued observers to the driver behavior that was to be watched and (2) provided a place to record the driver's response to trigger the later critique.

Vacuum Gauge

A vacuum gauge was used to provide instrument feedback to the Instructor/Instrument Feedback and Observer/Instrument Feedback groups ("Gastell" model 2006, by Automotive Devices, Inc.).

There are essentially two kinds of fuel-efficiency feedback devices: fuel flow meters and vacuum gauges. The first record the actual amount of fuel that enters the intake manifold. Once such a meter is installed, it provides a driver with direct information on the actual amount of fuel consumed in real time. Thus, fuel efficiency can be evaluated at all times, both when accelerating and decelerating, as well as when cruising at constant speeds. To be accurate, these meters must be highly sensitive, and their installation in the car is rather complex and expensive.

Vacuum gauges measure the amount of vacuum created in the intake manifold and are sensitive to variations in vacuum created during acceleration and deceleration. Fuel efficiency is greatest when the car moves at a constant speed, since the amount of vacuum is greatest and the engine has to work the least. In stop-and-go traffic, vehicle speeds are largely dictated by traffic and most of the fuel is consumed by accelerations and decelerations. Therefore, a vacuum gauge was considered adequate for the purposes of the study. In addition, installation is simpler than that of a fuel meter.

Fuel Efficiency Measures

The effectiveness of the various programs in leading to fuel-efficient driving was evaluated by use of both a knowledge test and performance measures.

Knowledge Test

Two 15-item knowledge tests were developed both as measures of student achievement and for comparing the effectiveness of the various programs in leading to acquisition of knowledge concerning fuel efficiency. One test was used as a pre measure and to determine the equivalence of the six groups, while the second was administered after completion of all instruction to measure of program effectiveness. Both tests employed triple-option, multiple-choice items sampling content from all areas of the course.

Performance Measures

The evaluation of student performance was conducted in a 15-minute drive following completion of instruction. The route was an in-traffic loop that began and ended at the high school. Six specific fuel-efficient behaviors were assessed at predetermined points along the route. The behaviors and measurements were:

> Acceleration From a Stop--The time it took subjects to accelerate from a stop to a fixed landmark was measured at two points along the route. An optimal time was determined by using the vacuum gauge to establish the quickest acceleration that would not set off the tone. The performance measure consisted of the absolute deviation (in seconds) from this optimal time.
>
> Hill Climbing--The speed at which subjects passed a fixed landmark at the bottom and top of five hills was measured. Whether or not they reaccelerated during the climb was recorded. The specific measures of performance were: (1) greatest initial speed at the bottom of the hill, (2) greatest reduction in speed between bottom and top of the hill without reacceleration, and (3) the absence of reacceleration.
>
> Speed Approaching Stops--At three locations along the route the driver had to stop in response to a stop sign or light. Fuel efficiency was measured by recording the driver's speed 2 seconds beyond the point when the stop light or sign could first be detected.
>
> Speed Deviation--Variability around the initial speed at which subjects entered "steady speed zones" was measured by recording the number of 1-mph deviations from the entry speed. Fuel efficient speed control was indicated by a minimal number of deviations.

Following Distance--Headway distances were measured in seconds while drivers followed other vehicles in the stream of traffic. Two road segments were denoted as "following distance zones." The shortest headway within each zone was noted. The greater it was, the more fuel-efficient the driver was considered to be.

Uncontrolled Left Turns--At two points along the route subjects were required to turn left at an uncontrolled intersection. Fuel-efficient performance was subjectively rated according to the criterion, "the driver made a reasonable attempt to time arrival at the intersection and avoid stopping for oncoming cars." Performance on this variable was scored "yes" (fuel-efficient), "no" (fuel-inefficient), or "n/a" (not applicable).

The rater reliability of the performance measure was assessed by having the two staff members ultimately responsible for giving the test administer it independently to the same drivers. The drivers were other members of the research staff who drove the route, deliberately making the types of errors that would be expected of novice drivers. Ratings were compared and measurement techniques revised to eliminate sources of disagreement. This was continued until a 95% agreement between the two administrators was achieved.

Administrative Procedures

Following administration of the knowledge pre-test, instruction and training began. With the exception of the Control group, which received no instruction or training, all groups of drivers received the fuel-efficient instruction as part of their regular driver education program.

The performance measures were administered to all six groups two weeks following completion of instruction and training. Students were tested individually, with the instructor and the test administrator riding in the car. Students were tested in the same vehicle in which they received their driver education training and with the same instructor they had throughout the course. The subjects were told simply to drive as fuel-efficiently and as safely as they could. The instructor's role was only to provide route guidance.

RESULTS

This section will discuss the results obtained from administration of the knowledge test and the performance measures.

Knowledge Test

The results obtained from the administration of the knowledge post-test to the six groups appear in Table 5 below.

TABLE 5

MEAN POST-TEST KNOWLEDGE SCORES

Group	N.	Mean Number Correct
Control	32	7.97
Classroom	17	8.42
Observer/Instrument Feedback	20	9.80
Observer Feedback	22	8.27
Instructor/Instrument Feedback	24	9.38
Instructor Feedback	26	9.11

Since the pre-test differences among the six groups were small and statistically nonsignificant, the post-test scores can be compared directly. An analysis of variance conducted on the post-test scores revealed significant differences among the six groups ($F = 2.78$ $p < 0.02$). The worst scores were recorded by the Control group. For drivers in this group, average correct response was 53%, whereas for other five groups combined, it was 60%.

A test of contrasts, comparing the Control group with the five other groups, was highly significant ($F = 3.88$, $p < 0.001$). While the Classroom group had a somewhat lower mean score than the four other groups, the difference was not significant.

Separate analyses of variance conducted on each of the four content areas revealed the largest differences in the vehicle operation items. Here, too, the Control group scores were the lowest, correct response again averaging 53%, compared with 71% correct for the groups receiving instruction.

In summary, the results indicate that classroom instruction was effective in increasing knowledge and that the addition of BTW training and feedback was not significantly more effective.

Performance Measures

Reliability

Since the six performance measures used were behavioral indicators of fuel-efficiency rather than direct measures of fuel consumption, it was necessary first to evaluate the reliability of the measures. This was accomplished by correlating performance measurements taken at different points, i.e., stopping performance at the three points where drivers were required to stop, vehicle following performance in the two zones where drivers were required to do so, etc.

Significant correlations were obtained for only three of the performance measures used: acceleration from a stop, speed approaching a stop, and hill climbing. The correlation was highest for accelerating from a stop. For the two checkpoints where this measure was recorded, the correlation was 0.58. For the three checkpoints where speed approaching a stop was measured, the correlations ranged from 0.34 to 0.49, and for the five locations where hill climbing was measured, the correlations ranged from 0.18 to 0.29. Although not particularly high, these correlations were both statistically significant and of some practical significance, especially if one takes into account the fact that actual performance at each point was subject to changing traffic conditions.

Results

Separate one-way analyses of variance were conducted on each of the fuel-efficiency performance measures. A lack of difference on the three measures for which reliability was not significantly greater than zero was expected. With respect to the three remaining measures, there was hope that some differences would emerge between the Control group and the treatment groups, as well as among the treatment groups.

No significant differences were obtained among any of the groups on any of the measures. In particular, no significant differences were obtained between any of the groups receiving instruction and the Control group. Some results are worth noting, however, with respect to each one of the more reliable measures of fuel-efficient driving.

Acceleration from a Stop

An examination of the individual data points revealed that without exception all drivers accelerated at a rate lower than even a normal rate of acceleration (e.g., approximately 0.2 g). This may have been due to the drivers' suppression of any natural tendency to accelerate faster. Factors that may have acted to suppress faster acceleration were (1) a belief that slower accelerations are fuel-efficient, (2) the inhibiting presence of instructor, and (3) a lack of vehicle control skill (compensated for by very slow acceleration).

It may be noted that during both training and administration of the performance measures, the vacuum gauge was frequently activated because of overacceleration. However, the overaccelerations were highly transient and appeared to be more a result of the student drivers' imprecise control of the accelerator pedal than of any deliberate attempt to obtain high accelerations.

The low accelerations recorded do not mean that the instructional program had been successful in overcoming any tendency toward fuel-wasting "jackrabbit" starts. Once the students gained confidence in their ability to handle the vehicle, and once an instructor was no longer scrutinizing their driving, their behavior could well change. Any effect upon acceleration patterns in real-world driving is more likely to result from classroom instruction designed to motivate students to use moderate, fuel-efficient acceleration than from behind-the-wheel instruction intended to develop skill in it.

Speed Approaching a Stop

An analysis of variance showed no significant differences among groups in speed approaching red lights and stop signs. The desired gradual reduction of speed while approaching stops requires that the driver respond to cues that are at some distance from his car rather than only to cues immediately in front of his car. There is ample evidence to indicate that novice drivers are unable to process cues as far in advance as experienced drivers (Mourant and Rockwell, 1970), raising the possibility that fuel-efficient driving instruction, at least with respect to planning ahead, should come at a later stage of the acquisition of driving skills.

Hill Climbing

Intercorrelations of measures taken in the five zones where hill climbing was assessed were the lowest of the significant correlations. This may be due, at least in part, to the interference of other traffic on the road. Hill climbing, nevertheless, was the only measure that showed a trend (though not significant) in the effect of training. On one hill there was a statistically significant difference between the Control group and the five treatment groups in both the initial speed at which the drivers approached the hill ($F = 3.68$, $p < .005$) and the speed reduction as indicated by the difference between the initial speed and the final speed at the crest of the hill ($F = 2.15$, $p = .06$).

A t-test of contrasts showed that the difference between the Control and Classroom groups combined and the four behind-the-wheel groups was also significant. The first two groups' average initial speed at the bottom of the hill was 25.5 mph, whereas the average speed of the BTW groups was 27.5 mph ($F = 3.07$, $p < 0.002$). The speed reduction of the BTW groups was also significantly greater than that of the Control and Classroom groups ($F = 2.40$, $p < 0.01$). The BTW groups averaged a speed reduction of 5.44 mph whereas the other two groups averaged a speed reduction of 3.93 mph ($F = 2.40$, $p < 0.01$). On three of the remaining four hills there was a similar, but statistically nonsignificant, trend: The BTW groups tended to reduce their speed more than the other two groups.

Driver Control Skill

Observations of student behavior during the performance measures indicated that low levels of driver control skill may account for the lack of differences among the five treatment groups and between the treatment groups and the Control group. Most of the students were still having great difficulty simply keeping the car in the lane and could spare little or no attention to the use of energy-efficient behaviors. Only for the hill climbing measures were there some significant differences and that is probably because a hill is a much more prominent cue than a stop sign or a left turn.

CONCLUSIONS AND RECOMMENDATIONS

The results indicate that classroom instruction can improve passive knowledge of aspects of fuel efficiency--at least in the area of the vehicle operation. Whether or not this information will be translated to actual behavior remains an open question. BTW instruction did not provide any benefit beyond that obtained with classroom instruction alone.

Unfortunately, the results of this study are not sufficiently conclusive to either support or refute the usefulness of fuel-efficient driving instruction in conjunction with driver training. The shortcomings of the present study were mostly due to the lack of reliability of the performance data. For the three more reliable measures, the reliability was still very low, thus imposing a low ceiling on the measures' validity. Even from a purely statistical point of view, one could not expect to find a strong relationship between a particular treatment and measure of low reliability.

Another conclusion that can be drawn on the basis of results is that instrument feedback does not provide any advantages over instructor feedback. Observations of drivers as well as interviews with them indicated that this is most likely due to the fact that the novice drivers are already experiencing a visual information overload and have no spare capacity to process information from an in-car device. If that is true, then instructor feedback should be as good as or better than instrument feedback, simply because the instructor can time his feedback better and does not add to visual overload.

Based on these conclusions, it was considered necessary to conduct another study in which larger samples of subjects could be studied and more reliable measures of performance could be generated.

STUDY OF INSTRUCTIONAL METHODS

Perhaps the most significant finding of the study described in the previous section is that BTW instruction does not provide any benefit beyond that produced by classroom instruction with respect to training in fuel efficiency. The results were not sufficiently conclusive to determine that BTW instruction is not useful. In the light of the rising costs of BTW instruction, there is an increasing tendency among high schools to eliminate it or to eliminate the whole driver education program. Therefore, it was considered critical to reassess the potential benefits of BTW instruction compared with those of classroom-only instruction. Accordingly, another study was instituted in which there was an attempt to improve the BTW and classroom instruction methods, as well as the measures used for evaluating driver performance.

METHODS

Revised classroom and behind-the-wheel programs were administered to a sample of high school driver education students. Fuel efficiency measures were used to assess the effectiveness of the programs.

Sample

The sample consisted of 114 students comprising five driver education classes at Friendly Senior High School in Oxon Hill, Maryland. Because classroom and in-car instruction were integrated and students had already been assigned to classes, it was not possible to assign students to experimental groups at random. However, no known biases had operated in the assignment of students to existing classes.

Experimental Groups

Three experimental groups were used:

1. Control--This group did not receive any instruction in fuel-efficient driving.

2. Classroom--This group received three 40-minute sessions of classroom instruction. The major revision was use of the project-developed film, "Safe and Fuel-Efficient (SAFE) Driver" to explain the DDE film and the discussion slide. Other revisions in instruction included: (a) eliminating homework in favor of classroom exercises, (b) simplifying exercises so that they could more easily be performed, and (c) improving the slide/tape presentations. Copies of printed material appear in Appendix A.

3. Behind-the-Wheel Training--This group received both classroom instruction and one hour of BTW instruction and feedback on fuel-efficient driving techniques. Since the previous study revealed that most students had difficulty just keeping their

car on the road, the BTW fuel-efficient driving lesson was given at the end of the driver education course. An attempt was made to improve BTW instruction by employing one instructional method that combined instructor and student feedback. A copy of an in-vehicle checklist appears in Appendix A.

Two classes were assigned to the Classroom group and two to the BTW Training group. The remaining class was assigned to the Control group. The number of students in each of the groups was as follows:

Control	23 students
Classroom	44 students
BTW	46 students

Fuel Efficiency Measures

Knowledge and performance were assessed as in the previous study. In addition, an opinion survey was used to assess the effect of the various programs upon attitudes toward fuel efficiency. Copies of the knowledge and attitude measure appear in Appendix B.

Knowledge Test

Two alternate forms of a 22-item knowledge test were developed to serve as pre- and post-tests. Those items from the earlier knowledge test showing the best discrimination served to form the core of the new test. Additional items were created to permit more intensive sampling of subject matter areas that were inadequately handled by the earlier test.

The two forms were equated as closely as possible with respect to both content and level of difficulty. However, since the effects of the program were assessed by post-test comparisons among the groups rather than by pre-post comparisons, exact equivalence was not necessary.

Opinion Survey

A 17-item opinion survey was developed to assess the effects of the programs on attitudes favorable toward fuel conservation. Each item consisted of a statement followed by three opinions relative to it. The opinions formed a scale of attitudes toward fuel economy. The survey was pretested in the Edgewood High School study. The pretesting consisted of administering a pilot version containing numerous items that were subsequently evaluated for internal consistency and discrimination. Items that did not discriminate were eliminated, and items that were not consistent with overall performance were either eliminated or modified.

Performance Measures

The performance measures used were similar to those used in the previous study and are listed below. Differences from the measures used in the previous study are noted. Speed Deviation and Following Distance were eliminated owing to their unreliability.

Acceleration From a Stop--Instead of recording total time to accelerate to a given point on the road, times of acceleration to 20 mph and 30 mph were recorded.

Approaching Stops--Three measures were recorded:

- Average Acceleration--Position of the gas pedal when the driver reached a predetermined distance from a required stop.
- Speed--The vehicle's speed at a predetermined distance from a required stop.
- Reacceleration--Whether or not the driver reaccelerated after making the stop.

Hill Climbing--Five measures were recorded: gas pedal position and speed at the bottom of the hill, gas pedal position and speed near the top of the hill, and whether or not the driver reaccelerated at any time between these two points.

Steady Acceleration--This measure was not used in the previous study. Steadiness of acceleration was subjectively rated from 1 (very poor) to 5 (very good) during accelerations from a stop. A dail attached to the accelerator pedal displayed acceleration variations as an aid in ratings.

Overall Performance Rating--This measure was not included in the previous study. It consisted of a subjective rating of overall performance in fuel-efficient driving on a scale of 1 (very poor) to 5 (very good).

Administrative Procedure

All subjects were administered one form of the knowledge test and the opinion survey prior to instruction. At the end of the driver education course, the opinion survey was readministered, along with the second form of the knowledge test. Performance measures were administered using procedures identical to those used in the earlier study. The individuals evaluating performance did not know to which of the three experimental groups a given subject belonged.

RESULTS

The discussion of results will include the knowledge test, opinion survey, and performance measures.

Knowledge Test

An analysis of variance conducted on the knowledge pre-test indicated small but significant differences among the three treatment groups ($F = 3.77$, $p = 0.025$). On the 22-item test, the Control and Classroom groups scored an average of 9.5, while the BTW Training group scored an average of 10.8.

To evaluate the effect of classroom instruction and of classroom instruction combined with BTW training, scores on the knowledge post-test were analyzed in both a one-way analysis of variance and an analysis of covariance in which the pre-test score was used as a covariant. The latter analysis was considered necessary to neutralize pre-course differences in knowledge.

Results obtained from administration of the knowledge post-test, adjusted for pre-test differences, appear in the table below.

TABLE 6

ADJUSTED MEAN KNOWLEDGE POST-TEST SCORES

Group	Mean Score
Control	10.7
Classroom	15.3
BTW Training	16.6

Performance was worst for the Control group, which averaged a score of 10.7, in compared with scores of 15.3 for the Classroom group and 16.6 for the BTW Training group ($F = 19.54$, $p < 0.001$). Thus, it appears that, at least as far as passive knowledge is concerned, classroom instruction is beneficial, and that BTW training has no significant benefits beyond those achieved by the classroom instruction.

Additional analyses of variance conducted separately on the specific categories of fuel-efficiency knowledge indicated that the improvement of the two treatment groups was consistent across all categories except vehicle maintenance, i.e., the instruction improved knowledge in vehicle selection, vehicle use, and vehicle operation. Failure to achieve significant improvement for vehicle maintenance is probably due to the limited instruction on the subject and the small number of test questions relating to it.

Because an independent evaluation of the two test forms was not made to assure that they were truly equivalent, a pre-post comparison of knowledge is not meaningful. Nonetheless, assuming that the Control group improved very little or not at all, the post-test scores indicate significant amounts of learning in fuel-efficient vehicle selection, use, and operation.

Opinion Survey

Since the same opinion survey was administered to all three groups, both before the program began as well as after the instruction, it was possible to make pre-post comparisons both among and within the groups.

Scoring of the survey consisted of assigning a grade of 1, 2, or 3 to the most desirable, less desirable, and least desirable opinion, respectively. Accordingly, a favorable attitude toward fuel saving would be indicated by a low score, the lowest possible score being 16 and the highest possible being 48. An analysis of variance conducted on pre scores indicated no significant differences among the three groups in terms of their attitudes toward fuel savings.

Results are shown in Table 7 below.

TABLE 7

MEAN PRE AND POST OPINION SCORES

Group	Pre-Test	Post-Test	Gain	p
Control	25.76	26.00	-.24	.39
Classroom	27.67	25.24	2.43	<.001
BTW Training	27.79	25.47	1.32	<.01

An analysis of variance conducted on the difference between the pre-test and post-test scores showed a significant difference among the three groups. The Control group deteriorated slightly, while the two treatment groups showed slight improvement. The improvement of the Classroom group was slightly greater than that of the BTW Training group although the difference is not significant.

The difference in post-test scores between Control and treatment groups is not as great as was the improvement within treatment groups. This is because the Control group had more favorable opinions to begin with. Groups that were more like the Control group might not be expected to show as much benefit from training as did the two treatment groups. Nevertheless, when pooled together, the subjects who received BTW training and/or instruction scored significantly better than the Control group ($T = 2.40$, $p < .0.1$). The Classroom group improved their score by 2.4 points (from 27.7 before) and the BTW Training group improved their score by 1.3 points (from 27.8 before).

Although the effects of instruction were significant, the degree of improvement was slight (2 points on the average, out of a potential maximum improvement of 11 points). Furthermore, even this degree of improvement cannot be accepted at face value because of the effect of social desirability, i.e., the tendency to give the "desired" answer even if one does not personally believe in it. It is very possible that social desirability evidenced its effect more strongly on those drivers who had already gained fuel-efficiency knowledge than on the Control group drivers, who did not have the same level of knowledge.

Performance Measures

Two kinds of analyses were conducted on the driving performance data. The first analysis was concerned with the reliability of the performance measures, while the second one was concerned with the differences among the three groups on these performance measures.

Reliability

As in the previous study, the reliability of each of the performance measures was evaluated by correlating performance measurements at different locations. Reliability would be reflected by high correlations.

Only four of the performance measures showed significant intercorrelations. These measures and their mean intercorrelations were:

- Speed Approaching Stop (mean r = .30)
- Acceleration to 20 mph (mean r = .37) and 30 mph (mean r = .25)
- Steady Acceleration (mean r = .61)
- Hill Climbing--approach speed (mean r = .22)

Although the correlations were statistically significant for all of these measures, they were nevertheless very low. This does not mean that the performance measures are inherently inaccurate. Rather, it means that differences in traffic conditions, road conditions and other factors resulted in differences among sampled performances. In any case, such low sampling reliability makes it difficult to assess differences between groups.

Results

In order to evaluate the effects of the classroom instruction and BTW training, an analysis of variance was conducted on each of the reliable measures of performance. Rather than conduct the ANOVAs individually on measures obtained at each location, a more stable measure of individual performance was obtained by calculating average score on each measure across all locations. In additiion, an analysis of variance was conducted on the subjective rating of the overall performance of each driver at the conclusion of the drive.

The analysis of variance tables for the reliable measures of performance and the overall rating of performance, together with contrast analyses appear in Appendix C. Mean performance scores for each group are presented in Table 8.

TABLE 8

MEAN OVERALL PERFORMANCE SCORES

Measure	Control	Classroom	BTW
Speed appr. stop	31.6	30.2	31.4
Time to 20 mph	8.01	8.06	7.61
Time to 30 mph	16.30	17.73	15.94
Steady accel.	2.93	2.95	2.99
Hill climbing	33.36	33.32	33.58
Overall rating	2.7	2.9	3.0

An analysis of variance revealed significant differences among the three groups in speed approaching a stop ($p = .05$). A test of contrasts showed the significance to be due to the difference between the Classroom and BTW Training groups. However, this difference was due entirely to the Classroom group, which averaged 1.4 mph lower than the Control group. Unfortunately, it also averaged 1.3 mph lower than the BTW Training group, which should have had the lowest approach speed.

There is no good reason why BTW instruction should have offset the benefits of classroom instruction. The unexpected pattern of results cannot be attributed to the measure itself since, as noted earler, speed approaching a stop was one of the more consistent measures. In the absence of any good rational explanation for the differences among the groups, the most parsimonious explanation for the origin of the differences is chance.

There were no significant differences in the overall rating of driver performance. Mean scores for all groups hovered around the average performance score. Although there was a numerical progression from 2.7 for the Control group through 2.9 for the Classroom group to 3.0 for the BTW Training group, these differences were both statistically and practically nonsignificant. Also, average time to reach 20 mph in accelerating from a stop, average maximum gas pedal depression during a steady acceleration, and initial speed in hill climbing all failed to show statistical significance.

The average time to reach 30 mph in accelerating from a stop was marginally significant ($F = 2.32$, $p = 0.10$). A contrast analysis indicated that this was due to a significant difference in the expected direction between the two treatment groups ($p = .015$). The BTW drivers required almost 2 seconds less to reach 30 mph than the Classroom drivers--15.9 vs. 17.7. The difference between the Control group and the two treatment groups was not significant.

An analysis of variance on the speed before a required stop was statistically significant ($F = 3.01$, $p = 0.05$). Again, however, the effect was due to a significant difference between the two treatment groups rather than between either one of the treatment groups and the Control group. In fact, the speed of the Classroom group was significantly lower (30.2 mph) than that of the BTW Training group (31.4 mph), indicating that their driving style is more fuel efficient. These results are hard to reconcile with any theoretical or intuitive expectations.

Discussion

It is possible that failure to demonstrate significant program effects is due to the low sampling reliability of the measures. It is more likely, however, that the causal relationships are reversed--that the low sampling reliability results at least in part from the failure of either instructional program to affect driving. Had the programs been effective, there would have been clear-cut differences among the students' driving performance. Those who had received instruction in fuel-efficient driving would have performed more fuel efficiently than those who did not. Those who had behind-the-wheel training practice would have performed more fuel efficiently than those who received only classroom instruction. Differences would have been observed on each measure at every location where the performance was observed and would have produced moderate to high correlations across sites.

On the other hand, with the lack of either training or driving experience to produce differences among individuals, there would be nothing to produce consistent behavior across sites. Performance would vary as a function of traffic conditions, momentary levels of attention, and other largely chance events.

There is no way of knowing for certain to what extent ineffective training led to unreliable measurement, and vice versa. However, it seems safe to say that if the training programs had been truly effective in leading to fuel-efficient behavior, differences among the groups would have been observed in the driver performance measures.

In summary, the analysis of driving performance failed to indicate any clear-cut advantages of either of the instructional programs in achieving the objectives of instruction.

CONCLUSIONS

The conclusions of this study can be divided into two categories: those concerning knowledge and opinions and those concerning driver behavior. As far as knowledge is concerned, the results demonstrate that classroom instruction is capable of achieving a significant improvement in driver knowledge in areas relevant to fuel-efficient driving. Furthermore, since the knowledge test was administered approximately three weeks after instruction, it is possible that these effects may be fairly enduring. The results also indicate that the added knowledge may, in turn, influence, albeit to a relatively small degree, attitudes toward fuel-efficient driving in the desired direction.

The effects of classroom instruction or BTW training on actual driving behavior are more difficult to assess on the basis of study results. While the results might appear to indicate that BTW training was effective in encouraging a brisk acceleration, the fact that the Control group fell mid-way between the two treatment groups suggests the pattern is due to chance. Furthermore, although the performance measures used yielded higher sampling reliabilities than the ones used in the Edgewood High School study, the reliabilities were still too low.

RELATIONSHIP BETWEEN ACCELERATION RATE AND FUEL ECONOMY

INTRODUCTION

Literature bearing upon the relationship between the rate at which a vehicle is accelerated and fuel economy, as indicated by mpg, is rather equivocal. The popular literature has emphasized the importance of a "brisk" acceleration in achieving maximum fuel efficiency (Hamilton and Carroll, 1980). The basis for this emphasis appears be uncontrolled observations of instantaneous mpg by drivers while accelerating at different rates. It is supported by the data presented in Figure 1, showing that mpg increased with mean acceleration up to a level of .16 g, the maximum employed by any driver.

Well-controlled studies involving precise measurement of fuel consumption, acceleration, distance, and maximum speed have produced different results. Jones (1980) found that the fuel required to reach fixed cruising speeds and cover fixed distances dropped off monotonically as acceleration rates increased from approximately .05 g to .23 g. However, the study was performed using dynamometers rather than moving vehicles. Evans and Takasaki (1981) operated vehicles over a test track; instead of a monotonic relationship, the authors found a curvilinear relationship. Their most fuel-efficient acceleration rate, however, was in the neighborhood of .08 g, far below what could be called "brisk."

In these two studies, the dependent variable was the fuel consumed in reaching a specified cruising speed, not in covering a specified distance. While vehicles accelerating rapidly consume more fuel in reaching a specified speed, they also cover more distance. Fuel consumed over a specified distance traveled is probably a better dependent variable because people drive cars to go from one place to another, not to reach a specified speed.

The lack of conclusive information about the relationship between rate of acceleration and fuel consumption greatly hampered the development and administration of the courses described in the preceding two sections. Acceleration is one of the more pervasive aspects of driving and one concerning which there is a great deal of curiosity on the part of students. The inability to provide guidance on the most effective acceleration rate was a distinct handicap.

In order to determine the relationship between rate of acceleration and fuel efficiency, a study was undertaken involving six vehicles instrumented to measure fuel consumption.

METHODS

The fuel consumption of six different vehicles was measured over a two-mile course at three different rates of acceleration.

Vehicles

The six vehicles, in increasing order of gross vehicle weight, were: a 1980 Plymouth Horizon, a 1978 Toyota Corolla, 1978 Chevrolet Malibu, 1972 Ford Esquire, 1971 Mercury Montego, and a 1979 Pontiac Trans Am. All had automatic transmissions. Each of the vehicles was equipped with the following:

- An accelerometer mounted on the dashboard to guide drivers in achieving specified acceleration rates.
- A Fuel Distance Trip Monitor to record the amount of fuel consumed between stops.

Five of the six vehicles were involved in the Home Vehicle Use Study described in Volume III of this report. A detailed description of the Fuel Distance Trip Monitor appears in that volume.

Acceleration Rates

The three rates of acceleration chosen were .1 g, .2 g, and .3 g. A test driver accelerated the vehicle until he achieved an acceleration at the prescribed level, which he held until the vehicle neared cruising speed. The target accelerations do not correspond directly to the average accelerations used in the studies mentioned earlier. Because of the normal slackening of acceleration as cruising speed is approached, the average accelerations would be somewhat lower. The three rates will be referred to as "low," "moderate," and "brisk," respectively.

Procedures

Each vehicle was driven over the two-mile course five times at each of the accelerations. On each run, the vehicles stopped at six points along the course, so that each vehicle was accelerated 30 times at each acceleration level. From each stopping point, the vehicles were accelerated at the prescribed rate to a speed of 30 mph. This speed was maintained until the vehicles reached a designated point, at which time the driver removed his foot from the accelerator and brought the vehicle to a full stop at the next designated point. The procedure employed held constant the total distance over which the vehicles drove on each trial, as well as the distance and fuel consumption involved in bringing the vehicle to a stop. The only variables were the fuel and time consumed in achieving and maintaining speed between stops.

RESULTS

The results obtained for each of the six vehicles appear in Table 9.

TABLE 9

FUEL CONSUMPTION BY ACCELERATION RATE

Vehicle	Acceleration Rate Low	Moderate	Brisk
Plymouth Horizon	.062	.064	.063
Toyota Corolla	.069	.068	.073
Chevrolet Malibu	.093	.096	.102
Ford Esquire	.154	.158	.164
Mercury Montego	.167	.157	.158
Pontiac Trans Am	.233	.196	.164
All light vehicles	.075	.076	.079
All heavy vehicles	.185	.170	.172
All vehicles	.130	.123	.126

Separate one-way analyses of variance conducted on each vehicle showed that the differences in fuel consumption by rate of acceleration were significant for all vehicles ($p<.05$). The variance across the five trials at a given rate of acceleration was extremely small--in some cases almost nonexistent, so that significance was obtained despite very small differences among acceleration levels.

While the relationships between acceleration and fuel consumption were consistent across trials for each vehicle, they differed from one vehicle to another. For three vehicles, the optimum acceleration was .1 g, for two it was .2 g, and for one it was .3 g, indicating that the optimum level of acceleration varies considerably.

The six vehicles in the present study were divided into two categories, those under 3,200 lbs and those over 3,200 lbs, referred to as "light" and "heavy," respectively. The studies cited earlier showed that larger vehicles tended to reach maximum fuel efficiency at somewhat higher acceleration rates than did smaller vehicles. The results shown in Table 9 are similar. The lighter vehicles were most fuel efficient at low accelerations, with efficiency dropping off slightly at moderate and brisk accelerations. The heavier vehicles, on the other hand, were more fuel efficient at moderate and brisk accelerations, with fuel efficiency dropping off markedly at low accelerations.

The absolute changes in fuel consumption were not great. The percentage change ranged from 1.6% to 20%, with an overall average of 5.7%. These differences in fuel consumption were realized on a test track where the vehicles were required to stop every third of a mile, conditions resembling stop-and-go city traffic.

A driver who accelerates rapidly usually is trading fuel consumption for time. The average times taken to complete the two-mile course under low, moderate and brisk accelerations were 5.3 minutes, 4.6 minutes, and 4.4 minutes respectively. Because driving time depends only on acceleration rate, it does not vary from one vehicle to the next.

The biggest savings in time came between low and moderate acceleration. Brisk acceleration did not save as much time as might be expected due to the quick easing off of the accelerator that occurs after a brisk initial acceleration.

DISCUSSION

The results of this study help to explain some of the disagreements registered in previous findings as to what is an optimal acceleration. It appears that what is an optimal acceleration depends on the weight of the vehicle.

A brisk acceleration was optimal for the heaviest of the six vehicles in the study. The second heaviest vehicle paid a penalty for brisk acceleration, but it was negligible. The DPMAS vehicle used to collect the data favoring high accelerations in Figure 1 was an extremely heavy vehicle with a large engine (needed because of the weight of the measuring equipment, the air conditioning, and the heavy-duty electrical system). Finally, most of the vehicles in which the efficiency of a brisk acceleration has been observed to be optimum are also full-sized "heavy" vehicles. In large vehicles, the ability of a brisk acceleration to get the transmission quickly into higher, more fuel efficient gears appears to offset whatever inefficiency there may be in the operation of the engine.

It cannot be claimed that brisk acceleration is more fuel efficient for all vehicles with large engines. Yet where it is not, the fuel penalty paid is a small one. It is worth pointing out, however, that the advantage in time saved is also very small. Drivers attempting to accelerate briskly tend, after the initial burst of acceleration, to slacken the pace markedly. The result is a savings in time of only about 5%.

Among lighter vehicles, the story is entirely different. First, the variation in fuel consumption across different acceleration rates is very small, from about 2 to 10%. The largest difference was that between a moderate and brisk acceleration. While a low acceleration was optimum for all three of the smaller vheicles, the penalty for a moderate acceleration was negligible. The time savings, on the other hand, averaged about 15%. A moderate acceleration therefore represents an optimal trade-off between fuel consumption and travel time for lighter vehicles.

It is obviously dangerous to generalize too far from results obtained on only six vehicles. Nevertheless, it seems reasonable to recommend that drivers be encouraged to employ a "moderate" acceleration as the best overall practice. More specifically:

- When driving vehicles with large engines, drivers should avoid very slow accelerations because of the time it takes to get the vehicle into more fuel-efficient gear ranges. They can employ a brisk acceleration without paying a significant penalty. However, they don't save a a significant amount of time.

- When driving vehicles with smaller engines, drivers should avoid brisk accelerations. With lighter vehicles, there is generally no penalty for low accelerations. While in some cases there is an improvement, it would not be worth the substantial increase in travel time for most drivers.

It is important to recognize that these findings apply only to vehicles with automatic transmissions. In vehicles with manual transmissions, fuel efficiency is determined as much by shifting technique as by acceleration.

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

SUMMARY

The results of the four studies are summarized below with respect to knowledge, attitudes, performance, instruction at the high school level, and optimum acceleration rate.

Knowledge

The first three studies taken together indicate that even at a time when the need for fuel conservation is apparent to most people, knowledge about ways to conserve fuel through vehicle operation, maintenance, and better trip planning is quite deficient. The deficiency may be due in part to prevailing misconceptions that are accepted by many people as facts. In addition, in some areas, the relationships between particular driving behaviors and fuel conservation is difficult to understand and depends on a variety of factors, such as vehicle characteristics and traffic conditions.

The second and third studies demonstrated that the principles and methods of fuel-efficient driving can be successfully taught in two hours of classroom instruction and that students can retain the information for at least several weeks. Yet, as long as knowledge is reflected only in paper-and-pencil tests, it must be considered passive, i.e., information that is not necessarily translated into actual behavior.

Attitudes

The instructional program resulted in more favorable attitudes toward fuel-efficient driving, but the changes were small. Moreover, there is always the possibility that they resulted, in some degree, from a combination of a desire to appear favorably disposed to fuel efficiency and an improved ability to do so because of knowledge gained from the program.

Given the generally favorable attitudes toward fuel-efficient driving revealed in the first study, the improvements in measured attitude produced by training probably reflect changes in opinion regarding specific issues rather than toward fuel-efficient driving in general.

Performance

The improvements in knowledge and attitudes concerning fuel efficiency were not accompanied by any change in measured behavior. There was a lack of individual consistency in fuel-efficient behavior as evidenced by low correlations between observations of the same behavior at different locations along test routes, and it is likely that this inconsistency resulted from the failure of the program to produce clear-cut behavior changes rather than from any inherent deficiency of the performance measures.

Fuel-efficient driving is a complicated behavior pattern. Fuel-efficient drivers must have a high familiarity with their vehicles, a familiarity that must be acquired through experience coupled with feedback. They must also be experienced at driving under different traffic conditions. The performance requirements are so complex that even with the aid of a fuel consumption meter, optimal performance is hard to achieve.

A primary requirement for coping with changing traffic conditions is the ability to plan ahead and anticipate potential problems. The data obtained in the second and third studies, as well as the observations of the researchers, indicate that novice drivers are too preoccupied with maintaining the car in the lane to preview the road ahead. Earlier studies also indicate that novice drivers are more concerned with lateral vehicular control, while experienced drivers are more concerned with anticipating future events (e.g., Mourant and Rockwell, 1970).

High School Instruction

It is possible that the benefits of fuel-efficient driving instruction will manifest themselves in performance after students have mastered basic vehicle handling skills and are able to devote attention to application of fuel-efficient driving techniques. This possibility could not be studied within the time and funds available to the project. It certainly seems likely that drivers who know what fuel-efficient driving techniques are and how much they contribute to reduced fuel consumption will be more likely to employ them than drivers who are uninformed on either score.

If the benefits of fuel-efficient driving instruction are evidenced only after driving skill has been acquired, it would appear that they are more dependent upon knowledge acquired in the classroom than upon training received in the car. If that is the case, it does not seem that a great deal is to be gained by trying to infuse fuel-efficient driving techniques into behind-the-wheel instruction. This does not mean that fuel efficiency should not become a part of in-car instruction; if people are to be taught how to drive, they might as well be taught how to drive fuel efficiently. However, it would suggest that developing skill in fuel-efficient driving techniques is not in itself a reason for providing behind-the-wheel instruction to novice drivers.

If drivers are to receive behind-the-wheel instruction, it would seem best provided after they have already mastered basic vehicle handling skills. Those training programs that have been evaluated and shown to result in reduced fuel consumption have all involved experienced drivers. Confining fuel-efficient driving instruction to experienced drivers would almost preclude its being made part of driver education. Most students take, and most schools provide, driver education in order to qualify students to receive a license. This is patently the case in those States where satisfactory completion of driver education is required for students seeking a license under the age of 18. Research elsewhere has disclosed that very few licensed drivers will volunteer for driving instruction (McKnight et al., 1980). High school students are not likely to be an exception. And the way in which driver education is funded in most States would make it very difficult for schools to provide behind-the-wheel training to drivers who are already licensed.

Optimum Acceleration Rate

Any conclusions based upon a study involving six vehicles obviously are limited in their generality. However, the fact that the results are generally consonant with those of previous studies gives them more significance than they would have by themselves.

If there is a single "optimum" acceleration, it is one that involves an acceleration pattern beginning from an initial .2 g acceleration. To most drivers, the term "moderate" would be an acceptable description of this acceleration rate. A moderate acceleration represents, for the majority of vehicles the most acceptable trade-off between the desire to conserve fuel and the desire to minimize travel time.

For heavy vehicles with large engines, a "brisk" acceleration in the .3 g range is just as fuel efficient as moderate acceleration. However, it does not save appreciably in travel time. On the other hand, "low" accelerations of .1 g or less are fuel inefficient and time-consuming for heavy vehicles.

For small vehicles, brisk accelerations are fuel inefficient, while low accelerations are just as fuel efficient as moderate accelerations. There is, however, no reason to employ low accelerations given the marked increase in travel time that they involve.

CONCLUSIONS

Based on the results of the four studies, the following conclusions can be made:

- High-school-aged drivers and driver education students have relatively poor knowledge of fuel-efficiency principles and facts. This is true for all four content areas tested: planning, operation, selection, and maintenance.

- Significant gains in knowledge can be achieved through classroom instruction.

- In the areas of planning, operation, and maintenance, high school students possess positive attitudes toward fuel conservation.

- When it comes to vehicle selection, high-school-aged drivers are not highly motivated to select a vehicle on the basis of its fuel efficiency rather than on the basis of other criteria.

- Instruction in fuel-efficient operating techniques does not appear to improve the performance of novice drivers. This lack of improvement is not influenced by the presence or absence of behind-the-wheel instruction or in-car feedback devices. It appears that the ability of novice drivers to control the vehicle is too marginal to permit them to develop or apply skill in fuel-efficient driving techniques.

- A "moderate" acceleration, involving an acceleration pattern with an initial .2 g acceleration, represents the optimum trade-off between fuel consumption and travel time in the operation of most vehicles. Low accelerations, with an initial acceleration of approximately .1 g or less, are fuel inefficient for large vehicles, while a brisk accelerations with an initial rates in the .3 g range are fuel inefficient for smaller vehicles.

RECOMMENDATIONS

On the basis of the findings obtained in the four studies and the conclusions reached, the following recommendations for action by NHTSA are offered:

1. Prepare the materials developed and evaluated by this project in a form suitable for widespread dissemination.

The fuel-efficient driving programs developed and evaluated succeeded in improving knowledge of and attitudes toward fuel-efficient driving including planning, operation, selection, and maintenance. The lack of observed change in measured performance is no reason to withhold the programs since (1) the performance measures encompassed only operation and not planning, selection, and maintenance; and (2) improvements in vehicle operating behavior might emerge after drivers are sufficiently skilled in basic vehicle control to be able to apply what they know. A demonstration of ability to change performance is rarely a requirement for implementation of an instructional program. In fact, only a minority of programs introduced into high school curricula can offer evidence of an ability to change knowledge or attitude, let alone an ability to change performance.

2. Undertake research to determine the long-term impact of fuel-efficient driving instruction upon driver performance.

While evidence of ability to affect performance should not be a prerequisite for implementation of a program of fuel-efficient driving instruction, the prospects for widespread implementation would be enhanced by the availability of such evidence. Evidence of long-term impact is not easy or inexpensive to obtain. Once high school students have completed driver education and obtained licenses, they are no longer as readily available for testing as when they are enrolled in driver education. Various attempts to obtain the cooperation of high school students have shown that financial inducements are necessary and must be fairly substantial if loss of a significant portion of the experimental sample is to be avoided. For this reason, federal funding is probably necessary for a conclusive evaluation of long-term impact.

3. Evaluate the effectiveness of instruction in improving fuel-efficient vehicle operation within a commercial fleet.

The findings discussed in this volume and the results of earlier research suggest that the prospects of obtaining improvements in the fuel efficiency of vehicle operation are greater among experienced drivers than among novices. As a setting for evaluation of instruction in vehicle operation, commercial fleets offer the following advantages:

- A strong financial incentive to provide the training.
- The ability to provide students and assure their participation.
- Sufficient mileage to permit the effects of instruction to reveal themselves.
- Fuel records capable of permitting assessment of program effects upon normal day-to-day vehicle operation.

Regarding the final point, there have been evaluations of instruction in vehicle operating techniques. However, none reviewed in the present study has been based upon accurate records of actual vehicle use.

REFERENCES

Evans, L., and Takasaki, G. M. Fuel Used to Accelerate Vehicles from Rest to Cruising Speed. Research Publication GMR-3555, General Motors Research Laboratory, March 1981.

Hamilton, Phyllis D., and Carroll, Laura J. Driver Efficiency Program Manual. Techniques and Resources for Conserving Transportation Fuel. Prepared for the U.S. Department of Energy, May 1980.

Jones, R. Quantitative Effects of Acceleration Rate on Fuel Consumption. U.S. Environmental Protection Agency Technical Report EPA-AA-SDSB-80-06, April 1980.

Klein, Richard H.; Allen, R. Wade; and Peters, Richard A. Driver Performance and Analysis System (DPMAS). Vol. I: Description and Operations Manual. Washington, D.C.: Government Printing Office, 1976. Prepared for the National Highway Traffic Safety Administration. NTIS No. PB 258 537.

McKnight, A. James; McPherson, Kenard; and Knipper, Anne C. Advanced Motorcycle Rider Course Plan: Final Report. Prepared for the National Highway Traffic Safety Administration, March 1980.

Mourant, R. R., and Rockwell, T. H. "Learning of Visual Patterns by Novice Drivers." Proceedings Federation Internationale des Societes d'Ingenieurs des Techniques de l'Automobile, Brussels, 1970.

National Safety Council. 1978 Driver Education Status Report. Chicago: National Safety Council, 1978.

APPENDIX A

PRINTED INSTRUCTIONAL MATERIALS

LESSON PLANS

- Lesson 1 - Driving to Save Gas
- Lesson 2 - Planning Travel to Save Gas
- Lesson 3 - Making a Fuel Economy Purchase

HANDOUTS

- Routes to Fuel Economy
- "Pick-a-Car" Activity
- Vehicle Selection Catalogue
- Fuel Efficiency Summary

Fuel Efficiency Performance Checklist

Narration for Slide-Cassette Presentation, "Short-Trip Penalty"

LESSON 1

DRIVING TO SAVE GAS

TIME ALLOTTED: 40 minutes

INSTRUCTIONAL OBJECTIVES

Each student will:

- o recognize the benefits to be gained by driving to conserve fuel.
- o know how to operate a vehicle in the most fuel-efficient manner and avoid gas wasting practices.

MATERIALS

Print piece - Routes to Fuel Economy

Film - S.A.F.E. Driver

Equipment - 16mm film projector

STUDENT PREPARATION

Students should read and study the sections of the hand-out Routes to Fuel Economy, on "Driving Skills" and "Vehicle Maintenance" before coming to class. (They may be given all four sections, but need not read the other two sections at this time.) They should also read the corresponding sections of the "Fuel Efficiency Summary."

SEQUENCE OF ACTIVITIES

1. Introduction to Fuel Economy - 5 minutes

Set the stage by asking students why it is important to conserve fuel. Briefly summarize four areas in which drivers can save fuel--vehicle operation, maintenance, purchase, and use of travel planning. Introduce the film, "S.A.F.E. Driver," by stating that it will focus on the first area--fuel-efficient operating techniques--though at the end it will touch upon the other three areas as well.

2. View Film - "S.A.F.E. Driver" - 15-20 minutes

3. Class Discussion - 15 minutes

On the board, before class, three columns of lines (blanks) should already be prepared with exactly enough blanks to fill in the chart of fuel-efficient operating techniques provided on page in the background section of this guide. To begin the discussion, ask the students what three categories of fuel-efficient operating techniques were presented in the film. List them at the top of each column as shown in the chart on page . Now ask the students to provide specific techniques to fill in the remaining blanks.

While there are many ways the behaviors could be listed, it would be best to guide their conceptualization to conform to the list provided. As each behavior is put on the board, the students should be able to say why it is fuel-efficient as well. Continue until the chart is filled in, prompting students or suggesting missing behaviors when necessary. You may also want to point out similarities or conflicts between fuel-efficient driving techniques and the safe driving techniques which the class has already learned.

4. Transition to Other Lessons - 5 minutes

Ask the class to name and summarize the three other areas of fuel economy and any specific behaviors mentioned in the film:

Vehicle purchase--buy the vehicle with the best mpg for the type of vehicle you need.

Vehicle maintenance--keep the car tuned and tires inflated to maximum recommended pressure.

Vehicle use (planning)--combine short trips into fewer longer ones.

- Emphasize that of the vehicle maintenance behaviors, maintaining tire pressure is most important because it's something many people don't already do.
- Point out that vehicle purchase and use (trip planning) will be covered in more depth in the next two lessons.
- Give reading assignment for Lesson 2.

LESSON 2

PLANNING TRAVEL TO SAVE GAS

TIME ALLOTTED: 40 minutes

INSTRUCTIONAL OBJECTIVES

Each student will:

- o understand the extreme fuel penalty exacted by cold starts and short trips.
- o recognize opportunities to combine trips or use alternatives.

MATERIALS

Audiovisual:

- o Slide/tape presentation - "Short Trip Penalty" (Activity 1)
- o Transparencies #1-4 (for Activity 2)

Equipment:

- o 35mm slide projector
- o Cassette tape recorder (synchronized to slide projector)
- o Overhead projector
- o Felt tip pen (for writing on transparency)

STUDENT PREPARATION

Students should read the section "Trip Planning Techniques" of the handouts "Routes to Fuel Economy" and "Fuel-Efficiency Summary" before coming to class.

SEQUENCE OF ACTIVITIES

Activity #1. (20 minutes) View Slide/Tape Presentation "Short Trip Penalty"

1. Set the stage by stating that although long trips (such as vacations)are certainly worth planning, short trips, being so numerous, require planning as well.

2. Briefly summarize the "plot" of the slide show before presentation so that students will be better able to follow.

3. Show slide/tape presentation "Short Trip Penalty" (10 minutes)

4. Briefly discuss questions students might have. Make transition to Activity #2 by telling students they will now get an opportunity to test their planning ability.

Activity #2. (20 minutes) Travel Planning Exercise

1. Showing transparency of "Neighborhood Map" (transparency #1) on the overhead projector, give students the following scenario:

   You are a houseguest at the Jones' on a typical Saturday.

   - At about 10 a.m. you go with Mr. Jones to Hardware A to pick up a spark plug wrench attachment for his rachet set. Once at Store A you find that they don't carry one that will fit, and so you must go over to Store B to get what you need. Then you return home.

   - After lunch, Susie Jones decides that it's time to get the aquarium filter which she forgot to pick up yesterday. At about 2 p.m. you go with her to the Pet Store and return home.

   - Just before dinner, Mrs. Jones asks you to go pick up some ice cream for desert at Grocery X, which you do.

   - Then at about 9:30 you go with Mike Jones to the drug store to get some mosquito repellent for the picnic tomorrow.

   When you return home, you find the Jones family sitting around the kitchen table discussing ways to cut down on the family budget. Thinking about the pattern of trips you saw them make today gives you an idea.

   You plot the distances the Jones' drove today in their single family car.

   Put down transparency #2.

Knowing the poor gas mileage that their car would get on short trips, you compute the gas consumed by the trips based on a stop-and-go city average of 10 mpg. This you do by dividing the miles travelled by 10. Then, also knowing the extremely poor gas mileage you get while a car is warming up, you add a quarter-gallon fuel penalty for each cold start (It generally takes a couple hours for the engine to cool down completely). Adding up the totals, you find that the Jones' car travelled 21.2 miles with 4 cold starts, using 3.1 gallons of gas at an average rate of 6.8 mpg.

While you're sure that the Jones' have no idea that those short trips around the neighborhood in their supposedly fuel-efficient car have cost them over $4.00 in gas, you want to be able to show them how much they could have saved if they'd planned their day's trips better...

2. Put down transparency #3. Have the class determine the most fuel efficient sequence of trips the Jones' could've made if they'd planned ahead. Guide the discussion so that the blank "Planned Trips" chart is filled in as shown in transparency #4.

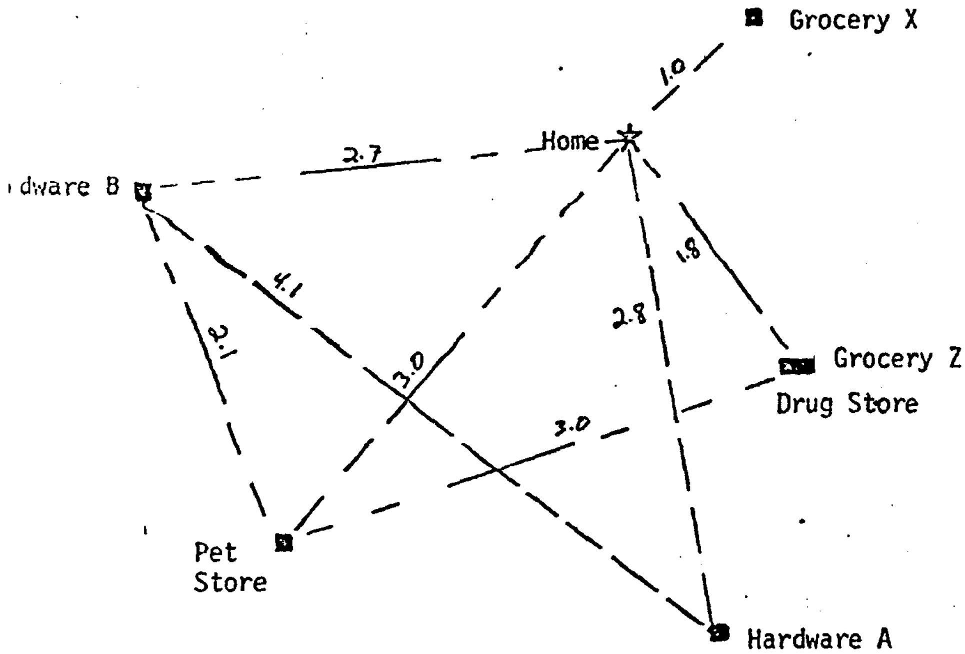
   Ask students what planning would be needed to make such a trip sequence possible. Point out that:

   - a family list of "Things Needed" could allow for the trip combination.
   - choosing a shopping center with more than one store (i.e., both a grocery and a drug store) could allow for the trip consolidation.
   - calling ahead to confirm that a store (i.e., Hardware A) has what you need could save an unnecessary trip.
   - making the sequence in the order shown, rather than in the reverse order, could save the ice cream from melting.

3. Put down transparency #4. Compare gas consumption, cost, and mpg for the planned and the unplanned trips. Discuss what accounts for the differences (cold starts, miles driven). Point out that the unplanned trips used almost 3 times the gas which the planned out trips required to accomplish the same objectives. Emphasize how such savings would be multiplied over the course of a year. Point out that driving time and wear is saved as well. Point out that more wear is put on an engine in the first 30 seconds on a cold start than in hundreds of miles of driving a warm vehicle.

4. If time permits, ask students to relate examples of good or poor trip planning from their own families' experience.

NEIGHBORHOOD MAP



JONES' TRIPS:

Time	C.S.	Destination	Miles
9:45		Home	
10:00	*	Hardware A	2.8
10:30		Hardware B	4.1
11:00		Home	2.7
2:00	*	Pet Store	3.0
2:30		Home	3.0
5:30	*	Grocery X	1.0
6:00		Home	1.0
9:30	*	Drug Store	1.8
10:00		Home	1.8

Totals- 4 cold starts 21.2 miles
÷ 10.0 MPG
2.12 gallons
*C.S. Penalty + 1.00 gallons
3.12 gallons

21.2 mi/3.1 gal = 6.8 mpg

PLANNED TRIPS:

Time	C.S.	Destination	Miles
9:45		Home (Call Hardware A & B)	
10:00	*	Hardware B	2.7
10:30		Pet Store	2.1
11:00		Drug Store	3.0
11:15		Grocery Z	0
Noon		Home	1.8

Totals: 1 cold start 9.6 miles
÷ 10.0 MPG
0.96 gallons
*C.S. Penalty + 0.25 gallons
1.21 gallons

9.6 mi/1.2 gal = 8.0 mpg

3.12 gallons
- 1.21 gallons

GAS SAVINGS = 1.91 gallons
x $1.30

MONEY SAVINGS = $2.48

Transition to Lesson 3

1. Point out that the fuel-efficient behaviors covered so far (operation, maintenance, and trip planning) benefit drivers by getting maximum gas mileage out of their vehicles, but that they are limited by the fuel consumption characteristics of those vehicles. Buying a more fuel-efficient vehicle is, therefore, the single most effective action a driver can take to reduce fuel consumption or get more miles for the same amount of fuel.

2. Make assignment for Lesson 3 (see Lesson Plan #3).

LESSON 3
MAKING A FUEL ECONOMY PURCHASE

TIME ALLOTTED: 40 minutes for classroom exercise

INSTRUCTIONAL OBJECTIVES

Each student will:

- recognize that choosing a vehicle for purchase is the most significant fuel economy decision a driver can make.
- know how to make a vehicle purchase decision based on actual driving needs and fuel economy factors.

MATERIALS

- Routes to Fuel Economy--"Vehicle Selection"
- "Pick-A-Car" Activity
- Vehicle Selection "Catalog"

STUDENT PREPARATION

Prior to Lesson 3, the instructor should hand out a copy of the "Pick-A-Car" activity and accompanying "Vehicle Selection Catalog" to each student. As homework, tell them to first read the "Vehicle Selection" section of Routes to Fuel Economy and the "Fuel-Efficiency Summary," and then attempt the exercise and be prepared to give and defend their answers in class. This is to give students a chance to familiarize themselves with the exercise before it is covered in class.* Make sure students bring both the exercise materials and the "Routes" and "Summary" sections with them to class.

SEQUENCE OF ACTIVITIES

Introducing the Exercise

Lesson 3 is centered aroung the classroom exercise "Pick-A-Car," which has students select a fuel-efficient vehicle for three hypothetical families. The instructor should introduce the exercise (with students using the Fuel-Efficiency Summary as a reference) by stating that of the four fuel-economy areas identified in the introductory lesson (Vehicle Operation, Maintenance, Selection and Trip Planning),

*In order to sufficiently impart the complexity of an actual vehicle selection decision, the exercise is probably too involved for students to successfully complete it on their own as a homework assignment.

fuel-efficient Vehicle Selection offers the greatest opportunity for saving gas. Whereas the other areas may yield savings up to 20-30%, mpg differences between different vehicles can be over one hundred per cent (e.g., the difference between a Plymouth Grand Fury rated at 16 mph and a Plymouth Champ rated at 37 mpg)!

The instructor should then hold up a copy of the 1981 E.P.A. Gas Mileage Guide, and explain that the information in this booklet (which is by law available in all dealer showrooms) allows the wise consumer to compare the fuel economy of different vehicles.

Explain that the E.P.A. ratings are not the actual mpg which the cars will achieve, but rather are estimates based on identical laboratory conditions and are to be used for comparisons only.

Point out to the students that because driving conditions and transportation needs will differ from family to family and driver to driver, E.P.A. estimates must be used in the context of the consumer's specific needs and other fuel economy factors. The purpose of the "Pick-A-Car" activity is to illustrate how this is down.

Conducting the Exercise (see also "Discussion Guide" below)

1. Ask several students which car they picked for the Smith family. After obtaining a variety of different answers, proceed to guide students through the Smith Family decision.

2. Repeat step 1 for the Jones and Ewing family purchases.

3. Discuss the "additional questions." This may be done either after all three problems have been worked through, or as each one is being discussed.

4. The end of the exercise includes an optional "home exercise," which the instructor may ask students to return alone, or together with a written assignment asking students to go through the steps necessary for selecting a new fuel-efficient vehicle for their own family.

Discussion Guide

Fuel Economy Framework

Fuel-efficient vehicle selection requires that drivers know both the effects of various vehicle features on fuel economy, and the proper way of applying that knowledge to the vehicle purchase decision. While changing technology may make the former "facts" obsolete, the latter "framework" will always be appropriate, and should therefore be emphasized in this lesson. Deserving particular emphasis is the importance of searching for transportation alternatives for "occasional" vehicle uses (e.g., renting a car to pull the boat-trailer to the lake three times a summer, rather than pay a year-round fuel penalty for a larger car).

Sample Answers

While sample "answers" to each family's vehicle selection probem are provided immediately below, the instructor should not feel restricted by them. Any answer which shows an understanding of the process involved is a "good" answer. In addition, the sparseness of the facts provided in each scenario provides a lot of room for the instructor to insert hypothetical facts for illustrative purposes. For example, "What if Mom and Sis only rarely went camping or skiing? Would that make a difference?" (Removable roof-rack vs. station wagon).

The Smiths' Sample Answer

I. Transportation Needs

- o Highway driving to work
- o 15 camping or skiing trips, occasionally with the whole family and their gear
- o Relatively few trips around town (e.g., roller rink)
- o Annual trip to Texas with the whole family

II. Vehicle Characteristics

- o Good highway mpg
- o Enough power and storage potential for occasional icy hill-climbing with a full load on ski trips (or alternative--rent-a-car or "removable" roof-rack)
- o Front wheel drive for traction (or alternative--snow tires or chains)
- o Four-adult passenger capacity (to give kids more room in back seat to Texas)

III. Vehicle Selection

Car (B2) gets the best highway mpg of all vehicles in the Table. Its passenger capacity is adequate, and it could be fitted with a removable roof-rack for the occasional trips where extra luggage space was needed (the cost of rental and aerodynamic drag should be far outweighed by annual fuel cost savings over the closest competitor vehicle).

However, B2's diesel engine has the least horsepower of any vehicle, which may create problems climbing hills on ski or camping trips with a full load (particularly on ice). If such occasions were infrequent, the inconvenience might be endured, or renting or borrowing another vehicle a practical alternative. Snow tires or chains would have to be used in the snow.

Station Wagaon (H) has the next-best highway mpg rating and substantially more power and interior space (both cargo and passenger). Although its city mpg is relatively lower, such driving is not a significant contributor to the Smith's fuel costs. Wagon (H) would thus be an acceptable alternative to Car (B2) if justified on these grounds. Again, snow tires or chains would be needed.

Car (A) has the third-best highway mpg, but lacks sufficient passenger capacity and is thus no improvement over (B2).

Car (C) also gets good highway mpg, has a 5-speed transmission for comfortable and efficient highway driving, has enough power, and in addition has front wheel drive for better traction on ice and snow. Though it lacks the interior space of Wagon (H), it has about the same as (B2), so might be justified on the basis of front wheel drive (particularly if a wagon was not desired by the family).

Cars (B2) and (C) and Wagon (H) are therefore all acceptable alternatives if justified on the basis of their different characteristics, and as long as the fuel costs of those characterisitcs are recognized. Car (C) and Wagon (H) will generally cost \$200-\$250 a year more in fuel, than (B2), although Car (B2's) costs may increase due to inefficiencies in power or size.

The Jones' Sample Answer

I. Transportation Needs

- o Take three large sons and football equipment to and from school
- o City excursions with entire family
- o Annual drive to Florida

II. Vehicle Characteristics

- o Five-adult passenger capacity
- o Good city mpg
- o Good highway mpg and load capacity (or alternative transportation to Florida)

III. Vehicle Selection

The single most important requirement is that the vehicles have at least a five-adult passenger capacity. The Jones' sons are big (the defensive line) and their parents are probably large as well.

The vehicle with the best city mpg that meets this requirement is Wagon (H). It also gets very good highway mpg for the trip to Florida. On that trip however (and to a lesser extent around town), its horsepower, and thus load capacity, may be inadequate to carry five two-hundred pound Jones' and their luggage. Its H.P. is only 76 and maximum recommended load is 850 lbs.

Car (E) gets about as good city mpg and better horsepower and load capacity. It may not make the trip to Florida either, but would probably do better around town. Flying to Florida might look more attractive when considering alternative vehicles.

Car (F2) has adequate power for the full Jones' load, and its diesel engine gets respectable city mpg. But is sticker price is over twice that of Car (E). $5,000 could buy a few plane tickets to Florida. Wagon (H) suffers a similar price difference. Car (G1) has a better sticker price (but slightly less power), but now we're getting below 20 mpg in the city.

All in all, overloading Car (E) slightly on the trip to church, and making alternative arrangements to Florida looks like the best bet.

The Ewings' Sample Answer

I. Transportation Needs

- o Haul one horse-trailer and hay
- o Take family (of five) to church
- o Long trips to promote widgets

II. Vehicle Characterisitcs

- o Sufficient power to pull trailer
- o Five-adult passenger capacity
- o Good highway mpg

III. Vehicle Selection

The first decision is which vehicle to replace (do not assume the Ewings have enough money to forego the trade-in). The decision is easy when we consider that the two fuel-inefficient requirements (power and passenger capacity) cannot be satisfied by the pick-up (five people cannot fit in the cab), but can be satisfied by the wagon (which itself gets slightly better mileage). That leaves the new vehicle to be purchased free to satisfy only the last requirement--good highway mpg. The choice is obvious--Car (B2) could probably save the Ewings over $2,000 a year. This example is a good illustration of the benefit of meeting different transporation needs with different vehicles (in multi-car families).

Choosing Options for the Vehicle

It is doubtful that fuel economy alone will prevent the selection of fuel-inefficient options if they are desired. The selection of fuel-efficient options, on the other hand, must be a balance of fuel savings and convenience against the initial price of the option (which varies greatly). The first point to be communicated to the students, then, is that all options have monetary costs and benefits which must be considered in addition to their convenience.

The second point to be made is that some options are more harmful or beneficial depending upon the vehicle and its intended uses. Air-conditioning is a fuel-inefficient option, but less so at high speeds (highway driving). A roof-rack is aerodynamically inefficient, but less so in the city (low speeds), and may actually be desirable if it allows a smaller car to be bought.

Some fuel-efficient options may be inappropriate as well, if they will undermine features for which the vehicle was selected. For instance, a vehicle which was selected for its ability to haul a trailer would probably be hurt by the power loss from a lowered rear axle ratio. On the other hand, fuel-efficient options may be particularly appropriate for some vehicle uses--such as front and rear spoilers for a salesman's car driven exclusively on the highway.

No list of "suggested options" for each family can be given. Instead, students should be able to justify options they choose in terms of their cost/benefit for the particular vehicle and type of vehicle use intended. Thus, the figures on the Option Sheet (which are estimates only) need to be adjusted with that in mind. Students should also be made aware that the estimated fuel costs/benefits on the Option Sheet may soon double or triple with the price of gas.

ROUTES TO FUEL ECONOMY

Every day, you make countless decisions that affect the amount of gas you need to buy.

- **Why, when, and how you travel**
- **How you drive your vehicle**
- **What vehicle you buy and**
- **How you maintain that vehicle**

determine how much fuel you need.

The U.S. Department of Energy thinks you can save 5 to 10% of the fuel you're using now by following the tips in this booklet. By making some changes in your travel habits, driving techniques, and vehicle type and maintenance, you could save as much as 40% of the fuel you now require.

Gasoline prices undoubtedly will continue to go up. By following these tips and techniques, your fuel requirements undoubtedly will go down.

ENERGY

DRIVING SKILLS

In Fuel-Economy-Challenge rallies sponsored by the U.S. Department of Energy, 80% of the participants achieved a higher mpg than the fuel economy estimate for their vehicle: You can, too, if you use fuel-saving driving techniques.

Thirty-Second Warmup

Remember, after you start up, idle for only 30 seconds before driving off.

After the 30-second start-up idle, drive at speeds of 25-35 mph for the first few blocks and the rest of your car will warm up. Only when it's very cold will you have to drive a longer distance than usual for your vehicle to warm up.

Moving Out from a Stop

When getting underway from a full stop, the most fuel-efficient thing you can do is to accelerate briskly and steadily (without flooring it). Once your car is traveling in the speed range where your engine operates most efficiently, your car's momentum will work for you—and your fuel economy.

Moving Up

By accelerating just before you begin to climb a hill, you'll get better speed for less gas than if you accelerated against the resistance of the grade. Near the top, ease off on the gas, allow your car's momentum to carry it over the crest, and cruise within the speed limit down the other side.

Maintaining a Fuel-Efficient Speed

All vehicles have a speed range in which they achieve their best fuel economy. This range varies, but most vehicles are more efficient at speeds between 35 and 45 miles per hour.

If your vehicle gets 22 miles per gallon in its fuel-efficient speed range of 35 to 45 mph, you can expect to get only about 20 mpg at a speed of 30 or 50. At 10 and 70 mph you'll get 14 to 15 mpg, you'll use a *third* more fuel than you would at 45 mph.

Changing directions or speed any more than you have to wastes time *and* gas. The slightest pressure on the brake or gas pedal costs you. Pumping the gas pedal is especially wasteful when you are starting your vehicle, getting underway, going up a hill, or trying to maintain your driving speed.
Smooth and steady does it!

Anticipating Traffic Conditions

Fuel-efficient response to anticipated traffic conditions can save more gas than any other driving behavior, particularly in city driving and rush hour.

Anticipating requires an alert driver who looks well ahead.

To maintain a fuel-efficient speed and flow smoothly through traffic, you've got to anticipate changes in conditions far in advance.

How far is far enough?

When you're looking about 12 seconds ahead, you can easily avoid unnecessary braking and acceleration and the small but wasteful changes in speed and steering.

In the city, looking 12 seconds ahead means anticipating changes in conditions for about a full block. On the highway, it means checking out and responding to changes in conditions up to a quarter of a mile away.

Observe the traffic conditions to the side and rear also. You need that information so that you can change lanes more smoothly when there are slowdowns ahead.

The Buffer Benefit

Anyone who wants to drive fuel efficiently will keep a buffer of space *all* around their vehicle.

Creating a buffer zone of about 2 seconds in front (on all sides if possible) pays off in four ways:

- More relaxed driving;
- More room to maneuver;
- More of a margin for safety;
- More time to react to conditions around you.

VEHICLE MAINTENANCE

Regular vehicle maintenance helps to prevent breakdowns and is an important aspect of fuel economy and driver safety.

Many maintenance tasks for fuel economy are simple to do and can be done at little or no cost to you.

Tires and Fuel Economy

The rolling resistance of any tire is greatly increased if it's not inflated properly.

Many drivers fail to keep their vehicle tires inflated to the maximum recommended level. If you are one of those drivers, you can expect a fuel economy loss of 1% for *every* 2 pounds your tires are below their recommended pressure.

Check your tire pressure during your pre-drive and service routine.

- Glance at your tires. Do any of them appear low?
- At least once a month, check your tires with a good tire gauge.
- Check troublesome tires (those that seem to lose air) more frequently.

Make these checks *before* driving. Tire pressure increases with the heat produced from driving, which can give you a high reading.

Keep these tips in mind:

- All vehicle tires should be properly inflated.
- Proper inflation for fuel economy means inflating tires to the *upper level* of the recommended range.
- Incorrect inflation causes unnecessary tire wear and affects vehicle handling.
- Tire wear and vehicle handling can be affected by *just one* low tire.
- Underinflated tires impose a fuel-economy penalty.

Gas and Oil

For the best price and fuel economy:
- Only buy the octane level gasoline your vehicle needs.
- Use the new high-mpg motor oils.

Octane levels are usually displayed on the pump and the correct level for your vehicle should be listed in your owner's manual. A practical guide, however, is to use an octane level just high enough to prevent engine knocking or "pinging" during normal driving conditions, or engine "run-on" when you turn the engine off.

Using a higher-octane gas than you need *does not* improve a car's mpg. Nor does it make up for a lack of maintenance.

An engine oil that is too thick will resist flow and increase friction among engine parts. And the more resistance your engine must overcome, the more gas you will have to use. So it's wise to use a multiple viscosity oil such as 10-40 or 10-50 oil which changes thickness in response to temperature changes.

While many factors influence a vehicle's mpg, reports indicate that the newer slippery oils may improve mpg by as much as 3 to 5%.

Maintenance Checks

You can prevent costly repairs by making some simple maintenance checks on your vehicle. It can help save you a little gas at the same time. A quick glance at your owner's manual will show you which checks to make.

Tune-up Requirements

It will help you get your best mpg if your vehicle is in tune and running well.

If your car is running poorly, a simple tune-up can improve your vehicle's fuel efficiency anywhere from 4 to 12% in most cases. For a vehicle that has been badly neglected, a tune-up can improve mpg up to twice that much.

The suggested schedule of tune-ups for your vehicle is discussed in your owner's manual. Of course, there will be times when your car won't need a complete tune-up. And if your car is running well and has no apparent problems, you should probably leave it alone (aside from routine care).

TRIP PLANNING TECHNIQUES

If you're like most drivers, you'll make about 1,400 trips this year and consume 800 gallons of gas. Your automobile expenses will represent about 15% of your household's total expenses.

With minimum effort, you can plan for more efficient travel and save gas, time, and money.

The Short Trip

Every day, the most frequently made vehicle trip is only 1 mile long. Trips of 5 miles or less make up 15% of all miles driven every year. But these *15%* of all miles driven yearly consume *30%* of all gasoline used by automobiles.

Why are short trips so expensive and so fuel inefficient?

The Cold Start and MPG

A vehicle operating from a cold start, say on a 4-mile trip, will probably achieve only 20% of the fuel economy possible after all parts of the vehicle are warm. That means if your car is capable of 20 mpg, you may get only 4 mpg under cold start/short trip conditions.

Cold starts impose a heavy fuel penalty on your mpg for several reasons.

- **Tire Resistance.**
  When your tires are cold, they resist motion. Tire resistance decreases only after you've driven your vehicle for a while.
- **Engine Resistance.**
  Engine lubricants are designed to reduce resistance. They perform best only after they have warmed up.
- **Vehicle Resistance.**
  All the parts of your vehicle resist motion at first. So all your vehicle parts must be lubricated properly. This occurs only after resistance is lower—after you have driven your vehicle about 15 miles.

If you combine several short trips into one longer one, you can diminish cold start penalties. Your initial fuel inefficiency could be offset by the average mpg achieved by using your vehicle for one longer trip, where your car can reach its maximum potential for fuel efficiency.

Vehicle Idling

The relationship between vehicle idling and fuel economy is misunderstood by most drivers. A 30-second warmup, followed by operating at slow to moderate speeds, is what's best for fuel economy.

Few of us ever think of the fact that when a vehicle is idling and not moving, it's getting its worst fuel economy—*0 mpg.*

A good rule-of-thumb is this: If the engine is warm and you expect to idle 30 seconds or more, it's more efficient to turn the engine off and restart it when everything is ready to go.

Idling can *save* gas if you take your foot off the gas pedal the moment you expect to slow down or stop. Lift the throttle to idle speed and coast. Your vehicle's momentum will generate the speed you need to drive safely.

Combine Trips

Planning travel can pay off in savings of gas, time, and money. The more trips you can combine, the more you can save.

When you combine trips, you'll reduce two big gas-eaters: cold starts and operating a cold vehicle. You save gas because the car's parts:
- have time to warm up.
- stay well lubricated for 15 to 20 minutes after individual stops.
- stay warmed up for 3 to 4 hours after stopping.

And if the trip is well planned, you will drive fewer miles.

How to Combine Trips

You can combine—
- trips that need to be made in the same time period, e.g., the morning.
- trips to the same general area or in the same direction.
- trips that can be plotted on a round-trip course.

If you can combine your trips—
- you'll spend less time behind the wheel.
- you'll find that some trips aren't necessary at all.
- you'll drive fewer miles to meet your travel needs.
- everything will get done—but at a lower cost.

Route Selection

Route selection applies to *all* trips. When planning your routes, you should:
- minimize your stops.
- maintain fuel-efficient speeds.

If necessary extend your route to avoid stop lights, traffic tie-ups, and stop-and-go driving situations. It's better to drive a slightly greater distance if you can drive smoothly and steadily in a fuel-efficient speed range.

Vehicle Loads

Cargo and passenger weight affect fuel economy. Weight causes mpg to drop. In fact, every 100 pounds of weight can penalize fuel efficiency by 3 to 6%.

It's also important to use the right vehicle for that load. A station wagon wasn't built to carry one person fuel efficiently. A compact wasn't designed to pull a trailer.

Loads should be carried inside the car—not outside—to reduce drag. Dead weight (the snow tires in your trunk) penalizes fuel economy mile after mile.

Travel Alternatives

Hopping in the car isn't always the best way to get what you need. Consider these alternatives:

- Ridesharing, mass transit, vanpools, carpools, and Amtrak with their high load factors can reduce personal costs and save time.

- Walking, bicycling, riding a moped or motorcycle can be especially efficient for short single-purpose trips.

- Many personal and work objectives can be met with a phone call. Call ahead to see if people are available or that stores have what you want.

- Use scheduled deliveries. If there's no real hurry, why worry about picking up and/or delivering something yourself?

- Shop by mail. More and more people are shopping with catalogs and doing business by mail. Often you can place your catalog order by calling a toll-free number.

Sharing Rides

Statistics indicate that few people think of sharing rides. In fact, studies show that more than 73% of workers drive *alone*. You may enjoy riding to work alone at times, but you could save substantially by sharing rides just two or three times a week.

You can also share rides while you're doing family business or on your way to a social event. You'll save on fuel costs, parking fees, vehicle maintenance costs, and tolls.

Ridesharing has other benefits. As fewer vehicles use the roads, look for:

- a reduction in congestion as well as in air and noise pollution.

- a reduction in the time it takes to drive from one point to another, particularly in densely populated areas.

People who rideshare get the best return on their transportation investment.

VEHICLE SELECTION

Choosing which vehicle to buy is the most important fuel-economy decision you can make.

Many factors affect your vehicle purchase decision. These include vehicle:
- Style
- Performance
- Make
- Safety
- Comfort
- Economy
- Dependability

But if you want to make the wisest vehicle purchase decision, you must ask:
- What are you going to use the vehicle for every day?
- Do the occasional special purpose uses justify the car-life expense?

The Fuel-Economy Framework

With fuel-economy considerations providing the framework upon which your vehicle selection will be based, you'll have to look at:
- **Miles driven.**
  The total miles you drive really influences gas purchase and vehicle operating costs. The way to reduce operating cost is to buy a high-mileage vehicle.
- **Type of trip.**
  Will your vehicle be used for a lot of short trips? Then mpg will be a major factor.
- **Number of vehicles.**
  If you own two vehicles, do they meet different needs? Is one of them more fuel efficient?
- **Common load.**
  How many people and how much cargo will be carried in the vehicle—every day?

Keep the answers to these questions in mind when you're looking at vehicle design, weight, engine size and type, fuel efficiency, and option efficiency.

Determining Size

Which vehicle size meets your transportation needs the best? The classes of vehicles include: two-seater, mini-compact, sub-compact, compact, mid-size, large, small station wagon, mid-size station wagon, large station wagon, small pickup and standard pickup truck, van, and special purpose truck.

Once you've established what size vehicle you need, review the mpg estimates and information in the *Gas Mileage Guide* for that class vehicle. The *Guide* is available, free by law, at new car dealerships. Key comparative mpg information is also displayed by law on every new car.

What to Expect from Estimates. *Mileage Guide* estimates assume that the vehicles are broken in and are driven in warm, dry weather on level roads. The tests for all the vehicles are done under exactly the same conditions and represent average driving conditions.

You may not get the mileage estimated for any particular vehicle. Many factors, including your driving habits, road conditions, the type of trips you make, and vehicle condition, influence your mpg.

You should study the *Guide* to select a vehicle with the highest mpg that meets your other important purchase considerations.

If a mid-size is indispensable for your travel needs, then select a mid-size from among the most fuel-efficient mid-size vehicles.

Specifications for Fuel Economy

Other vehicle specifications must be considered when choosing a vehicle for the greatest possible fuel economy.

The major ones include:
- Vehicle weight
- Load
- Aerodynamic design
- Vehicle axle
- Engine size and type
- Tire selection
- Vehicle transmission
- Power options

Vehicle Weight
Vehicle size is secondary to vehicle weight for fuel economy.

As a general rule, fuel economy is reduced from 1 to 5 miles per gallon for every 500 pounds gained in vehicle weight.

Load
That "small is beautiful" is not an inflexible fuel-economy maxim.

A small station wagon that must pull a trailer frequently may have to work so hard that your fuel economy is sacrificed. And if that's the load your vehicle will need to carry often, then a mid-size station wagon may be your best bet.

Aerodynamic Design
The smaller the frontal area of a car, the better gas mileage it will get. When air resistance is lowered, fuel economy increases.

But take into account your travel habits. If most of your driving will be at moderate (45 mph or slower) speeds, the effect of frontal design on gas mileage will be minimal. If most of your driving will be at highway speeds, frontal design could be a factor.

Engine Size and Type
Selecting the smallest engine that meets your needs and matching it to your model choice is the best idea. A small engine in a small car is usually most economical, but it's not as economical if loaded down with heavy power options.

So figure on comparing the fuel-efficiency ratings of your model choice and options with engine size to get the combination that gives you the best mpg. Usually it's a four-cylinder engine for a small car, a six-cylinder for a large one, and an eight-cylinder for a car that has to carry heavy loads nearly every day.

Diesel or Turbo-Charged Engines
Diesel or turbo-charged engines are other energy-saving alternatives.

A vehicle powered by diesel fuel is capable of getting 25% or more mpg than an identical gasoline-powered vehicle.

With a turbo-charger, a smaller engine has the power of a larger engine on demand, but it allows more efficient normal driving with efficient extra power available.

Vehicle Transmission
It used to be a fairly firm rule that a manual transmission was more fuel efficient than an automatic. The newer automatic transmissions are lighter, and improvements such as torque converters and lower gear ratios make them more fuel efficient than they used to be.

With all other factors equal, a conventional automatic transmission, compared to a standard, can use more fuel. But an unskilled driver of a manual transmission may consume a greater amount of fuel by stalling the engine, running in the wrong gear, or revving the engine while shifting. So if you drive mostly in the city, are not a smooth shifter and are not willing to become one through practice, it might be more fuel efficient to go with an automatic.

Vehicle Axle
The rear-axle ratio is defined as the number of times the drive shaft must rotate to turn the wheels one time. A low rear-axle ratio is normally more efficient than a high ratio because the engine must power the drive shaft fewer times to turn the wheels once.

So, the lower the axle ratio, the better the mileage. And the less wear on the engine.

Tire Selection
When you buy radial tires you are probably making your most important fuel-economy purchase decision—aside from selecting the basic vehicle itself. Radial tires can provide a substantial 3 to 7% improvement in your mpg over conventional bias-ply tires in highway conditions.

Radials are built to minimize rolling resistance. And while they may cost more than other tires, they tend to last twice as long and help improve vehicle handling.

Power Options
Power options will increase your vehicle's power requirements in two ways: by using power themselves and by adding weight.

If you own a small car, power options will penalize your gas mileage even more than on a larger car, because the added weight and power requirements are an added strain. Most power options are not necessary on a small car.

If you want "something extra," choose luxuries like super sound equipment or plush leather seats that add to your enjoyment without subtracting from your mpg.

Air Conditioning
Some air-conditioning units can add as much as 100 pounds of weight to a car and in city driving, can cause a 1 to 3 mpg reduction in fuel economy.

Designers are creating more efficient air-conditioning equipment all the time, so the penalties aren't what they were. It's how you use the air conditioner that makes the difference.

The most fuel-efficient cooling is with windows up and flow-through ventilation on. If you must adjust the temperature in the vehicle, use moderate settings.

PICK A CAR ACTIVITY

The Smiths, Jones', and Ewings all want to buy new vehicles. Read the brief descriptions of each family and choose a new fuel-efficient vehicle for the family from the Vehicle Selection Table provided. You need not choose the car that has the best mileage ratings, but you should be able to explain why other factors were more important. Justify each choice along the lines suggested by the answer guide which follows. Then answer the additional questions. Information in Routes to Fuel Economy should help you understand the importance of different automobile characteristics and how they relate to fuel consumption.

FUEL ECONOMY FRAMEWORK

For each family, you should consider:

What are the family's transportation needs (i.e., list the important types of trips)?

What vehicle characteristics will allow each of the transportation needs to be met?

Can alternative means of transportation (e.g., renting or borrowing a car, trailer, etc.) be found to reduce the number of fuel-inefficient characteristics required?

Which vehicle(s) provide the best compromise of transportation requirements and fuel-efficiency? Why?

Additional Questions

1. From the table provided, which options would you advise each family to put on its new vehicle? Are there any options appropriate for one family that would not be appropriate for another? What is the fuel cost or benefit of these options?

2. Was the E.P.A. estimate alone sufficient to choose the most fuel efficient vehicle in each instance? Why or why not? If not, which requirements would a vehicle with a better mpg rating have sacrificed?

3. The Vehicle Selection Table gives an estimate of the annual fuel costs associated with each vehicle. For each family, compare the vehicle you have chosen to the vehicle with the highest annual fuel costs. How much have you saved them? Compare your choice to the vehicle with the lowest fuel costs. The difference (if any) represents what they will pay each year for more size or power.

THE SMITHS

When the Smith family's only car broke down again for the hundredth time, Mr. and Mrs. Smith decided to get a new car instead of trying to fix the old one. The family was excited about choosing a new car and each member argued for the type of car he or she wanted. Mrs. Smith called for a family meeting to sensibly discuss what the family needed in a new car. She asked each family member to think about what kind of trips they'd need to be making, to get a better idea of what to look for in the new car.

"First," stated Mrs. Smith, "I guess we should begin with driving to and from work. Even though Dad and I travel together, it is still 15 miles each way on the freeway. (Mrs. Smith did some quick calculations.) "That's over 6500 miles of highway driving a year just getting to work and back."

Jeff, who had recently gotten his driver's license, added, "Dad and I take a lot of gear on our skiing and camping trips and that's more than we can put in the trunk."

"But that's all right," Mr. Smith interrupted, "When Mom and Sis come, we can rent a roof rack. Besides, we only make the 200 mile round-trip about 15 times a year."

"We could use a car that gets good traction, though," Jeff continued. "Dad ran into three snowbanks last year going to the ski area. The Browns' front-wheel drive car works great in the snow."

Suddenly 12-year-old Julie chirped up, "Remember, you promised that you'd take my three friends and me to the roller rink every Friday. That's all I care about."

Mrs. Smith reassured Julie, "Don't worry about your roller rink trips; it's only once a week and 5 miles each way. We could easily crowd four or five of your friends in any car for that short a trip. However, I like Jeff's idea of getting front wheel drive. We had snow on the ground from the beginning of January until mid-March last year."

Mr. Smith nodded his head in agreement. "The one other request I have is that the car be big enough so that Jeff and Julie have room in the back seat when we drive to Texas this summer. It's a thousand miles each way and the kids always get fidgety because the weather is hot and there are only a few hills to serve as diversions. A car that can carry four adults wouldn't cramp the kids as much."

Mrs. Smith took out a pen and wrote the following figures on her napkin:

Total miles the car was driven last year	15,000 miles
Highway driving (skiing and camping trips, to work, and to Texas)	11,500 miles
City driving	3,500 miles

Choose a new fuel-efficient car that meets the Smith family's needs.

THE JONES'

Jim Jones had been thinking about buying a new fuel-efficient car ever since he had waited in two-hour gas lines during the 1979 oil crisis. Now he sat down and thought about his family's minimum travel requirements to see how he could best replace the family's only car. Jim had a strong incentive to buy a cheaper, more economical vehicle. He had invested heavily in Florida swampland and needed to save as much money as possible to offset his losses.

Jim and his wife Barbara had been using the buses to get to work for several years. The cost in gas and parking fees was too large to allow either of them to drive to work alone, and they could not drive to work together because each worked in opposite directions from home.

Instead, the Jones' allowed their three sons to drive the car to school each day. Ralph, Peter, and Bob were the defensive line for the high school football team and practice ended too late for them to catch the school bus home. Either someone would have to pick them up after practice or they would have to take the car.

The Jones family was very city-oriented. Jim and Barbara would rather go to the movies on Saturdays than to the mountains. Their car was used regularly for excursions around the city, and often held all five family members on these local trips. The only long trip they took was an annual drive to Florida of 1,000 miles each way to see their grandmother. Jim Jones estimated that highway miles accounted for only 1/5 of the 15,000 miles the family had put on the car last year.

Which vehicle should the Jones family purchase?

THE EWINGS

Papa Ewing was going through his bills. He picked up his gasoline bill and angrily made out the check. The family had been driving each of its two vehicles 15,000 miles a year. The pick-up truck was getting only 8 mpg and was costing $1900 each year in gas alone. The family car, a station wagon, wasn't doing much better at 11 mpg and $1350 in annual fuel costs. Papa decided to replace one of the vehicles.

He remembered that he had purchased both the pick-up and the station wagon because all three of his kids had been living on the little ranch. Each had owned a horse and Papa had needed to haul the trailers and the hay. He needed the stationwagon to haul the children. Bobby and Jason had moved down the road last year, though, and they had taken their horses with them. That left only Barbara Jean and her horse to contend with.

Papa talked about the problem with Mama Ewing. She didn't care which vehicle was replaced so long as the family had one vehicle left that could carry the family as a whole, including Jason and Bobby, to church together on Sundays. For the rest of her trips, any vehicle would do.

Papa then thought about his own driving. Most of it was long trips he made alone to promote the widgets he sold for a living. He had been putting on most of the family's miles driving up and down highways with his small promotional kit, which would fit in the trunk of any vehicle. He figured that he could do all his driving in the new vehicle instead of splitting his travels between the station wagon and the pick-up as he had done in the past.

Since there was only one horse left to be transported, Papa knew he could get by with either the old station wagon or the old pickup. He was left to decide which vehicle he should replace and which new vehicle to purchase in its place to gain the largest reduction in his annual fuel bills.

Choose a new vehicle for the Ewings from the list provided. Indicate which vehicle you decided to replace and how the new vehicle, together with the old vehicle the family is keeping, solves the transportation needs for the Ewing ranch in a fuel-efficient manner. Check the table to find out how much the new vehicle will reduce their annual fuel bills.

HOME EXERCISE

Take this problem home and ask your parents to help you with it:

What kind of mileage does your own family's present car(s) get? Use your car's mileage rating in the following formula to determine your car's present annual fuel costs.

$$\frac{\text{15,000 (avg. miles per year)}}{\text{mpg your car gets}} = \_\_\_\_\_\_\text{(annual gallons consumed)}$$

Annual gallons consumed______ x \$1.30 (approximate cost of gas)

= ______(annual fuel costs)

How much could a new fuel-efficient vehicle (from the table) save you each year?

FUEL-EFFICIENT VEHICLE SELECTION CATALOG

Vehicle Selection Table Lists specifications for thirteen 1981 model year vehicles available for purchase now:

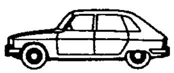
Weight -- Actual measure for standard vehicle
Cargo Space -- Actual measure, useful for comparison
Passenger Capacity -- A = Adult, C = Child (Generally, 3 children = 2 adults)
Maximum Load -- Estimate of maximum load weight (including passengers) which should generally be carried.
Transmission Type -- Manual (4- or 5-speed) or automatic. Rear wheel drive unless specified otherwise.
Engine Type and Size -- Size (displacement) in cubic centimeters. Gas burning-unless (D) signifies diesel.
Horsepower -- Useful for comparison
EPA mpg -- Estimates of stop-and-go and highway mpg respectively/useful for comparison
Fuel Tank Capacity -- How far between fill-ups (gallons)
Base Price -- Actual figures with standard equipment only
Yearly Fuel Costs -- Based on combination of highway and city estimated mpg for 15,000 miles at $1.30/gallon
All vehicles come with radial tires as standard equipment

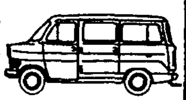
Option Information Sheet Provides a representative sample of currently available options and their effect on fuel costs.

Estimates the average dollar increase or decrease in annual fuel costs for similarly affected vehicles in three groups.

Options' initial price is not indicated.

VEHICLE SELECTION TABLE

	Weight (lbs.)	Cargo Space (cubic feet)	Passenger Capacity (Adults/Children)	Maximum Load (lbs.)	Transmission Type	Engine Type & Size (Gas/Diesel) (cubic centimeters)	Horsepower	EPA City MPG	EPA Highway MPG	Fuel Tank Capacity (gallons)	Base Price (U.S. dollars)	Yearly Fuel Costs (U.S. dollars)
CAR A 	2000	9	2 A + 2 C	700	4 speed manual	1600	70	30	39	12.5	$5,400	$599
CAR B 	1850	15	4 A	600	4 speed manual	1460 1600 (D)	62 48	24 38	36 54	10.9	$5,700 $6,300	$721 $454
CAR C 	2075	11	4 A	775	5 speed manual front wheel drive	1800	79	26	36	12.2	$6,395	$679
CAR D 	2425	29	2 A + 2 C	850	4 speed manual	2300	88	17	29	13	$4,451	$988
CAR E 	3100	15	5 A	900	4 speed manual	2300	88	23	29	18	$4,849	$788
CAR F 	3924	23	6 A	1175	auto.	5000 5700 (D)	150 135	17 21	27 31	25	$9,742	$1005 $828

CAR G 	3222	15	5 A	1175	auto.	3300 5000	100 134	18 16	24 22	18	$4,849	$992 $1,108
STATION WAGON H 	2402	42	6 A	850	4 speed	2200	76	24	40	13	$7,064	$703
STATION WAGON I 	3600	62	9 A	1375	auto.	5000	120	13	26	20	$8,550	$1,250
PICKUP J 	2500	pickup bed	2 A	1450	4 speed manual	2000	81	27	38	10	$5,300	$652
PICKUP K 	2900	pickup bed	3 A	2000	auto.	5800	145	13	22	16	$6,200	$1,295
PICKUP L 	3000	pickup bed	3 A	2000	auto. 4-wheel drive	5800	145	12	20	16	$6,600	$1,408
VAN M 	3700	155	2 A	1800	auto.	5800	145	13	24	17	$6,920	$1,270

OPTION INFORMATION SHEET

The numbers represent dollar approximations of the change in a vehicle's annual fuel bill as a result of an option. Positive numbers indicate increased fuel costs, negative numbers indicate reduced fuel costs. All numbers are estimated averages only.

	Vehicles A, B, C, H, J,	Vehicles D, E, F, G,	Vehicles I, K, L, M
Air Conditioning	+33	+32	+33
Automatic Transmission (if vehicle has a manual transmission as standard equipment)	+51	+42	NA
Overdrive or Fifth Gear (only available with a manual transmission)	-30	-42	NA
Power Windows, Power Radio Antenna Power Brakes	+24	+14	+14
Radial Tires (replacement only)	-30	-62	-83
Luggage Rack	+24	+31	+39
Front and Rear Spoilers	- 7	-11	-15
Electrical Fuel Injection and Electronic Ignition	-30	-42	-57
Lower Rear axle Ratio	-15	-22	-29
Tachometer and Cruise Control	- 6	- 9	-12
Power Steering	+25	+29	+38

FUEL-EFFICIENCY SUMMARY

VEHICLE OPERATION--IMPORTANT POINTS

1. For most vehicles, driving between 35-40 mph uses less fuel per mile than either higher or lower speeds.

2. Driving in higher gears uses less fuel per mile than driving in lower gears does.

3. Smooth and steady acceleration from a stop allows the vehicle to use less gas by reaching the upper gears and fuel-efficient speed range more quickly.

4. The most fuel-efficient way to climb a hill is to accelerate slightly before the hill, maintain a constant accelerator pressure, and let speed drop off--without having to re-accelerate.

5. Taking your foot off the gas as soon as you know you'll have to stop can save a lot of wasted gas.

6. Looking twelve seconds ahead, keeping a 2-second buffer of space, and anticipating what's coming up, allows the driver to save fuel by conserving the vehicles's momentum.

7. Additional Information:

   - The best way to start a cold engine on a newer model car is to press the gas once to set the choke before turning the key. Avoid pumping the gas or revving the engine.

   - The best way to warm a cold vehicle is by driving slowly. That way, the whole vehicle, not just the engine, warms up.

   - Fast highway speeds can substantially decrease mpg for long periods of time, particularly for smaller cars. For example, a sub-compact driven at 70 mpg may get 40% less mpg than when driven at 50 mph.

VEHICLE MAINTENANCE--IMPORTANT POINTS

1. Maintaining maximum tire inflation is the single most important maintenance habit for fuel economy.

   - Tire pressure should be maintained at the top end of the recommended range printed on the tire.

   - 55% of all drivers are currently losing up to 2 mpg every day because of under-inflated tires.

   - This penalty (and excessive tire wear and poor handling) can be produced by just one low tire.

2. Vehicles should always be kept in good running condition.

VEHICLE SELECTION--IMPORTANT POINTS

1. Making a fuel-efficient vehicle selection is the single most important thing a driver can do to save gas.

2. Vehicles in different class sizes can vary by 100% in the mpg they achieve.

3. Vehicles in the <u>same</u> class size can vary by 100% in the mpg they achieve.

4. EPA mileage estimates are based on simulations under controlled conditions which allow for <u>comparison</u> among vehicles.

5. <u>Weight</u> is the single most significant vehicle-factor affecting fuel economy. <u>Engine</u>-size is also important.

6. The fuel-efficient vehicle selection framework:

   a) Determine your vehicle-use needs.
   b) Translate those needs into vehicle characteristics which will satisfy them.
   c) Look for ways to reduce the number of fuel-inefficient characteristics required.
   d) Select the vehicle in your price range that will get the best mpg and has the characteristics you require.

7. Additional Information:

   - Fifth gear (overdrive) improves <u>highway</u> fuel-economy by allowing the engine to turn more slowly. A <u>lower rear</u> axle ratio does the same thing <u>all</u> the time, but sacrifices a little power.

   - While cruise control can save gas by reducing unnecessary speed fluctuation on the highway, an aware driver can save even more without it by allowing speed to drop off on hills.

   - Aerodynamic drag which decreases mpg (particularly on the highway) can be improved by front and rear spoilers. It will be worsened by a roof-rack, particularly when it's loaded up.

   - Air conditioning uses up more gas at low speeds than at higher speeds. When <u>idling</u>, the fuel penalty is highest of all.

   - All new cars now come with radial tires as standard equipment. They provide up to 7% better fuel economy, better wear, traction, and handling than bias ply, and should be chosen for replacement tires as well.

TRIP PLANNING--IMPORTANT POINTS

1. Cold starts and stop and go driving can reduce fuel economy by <u>50%</u>; even more for very short trips.

2. Cold starts also account for most engine wear. More wear is put on an engine in the first 5 minutes after a cold start than in 500 miles of warmed-up highway driving.

3. A vehicle can become cold after sitting for just a few hours; even less in cold weather.

4. Combining trips saves gas and wear, both by eliminating unnecessary miles and by making more of the travel with a warm vehicle.

5. Driving a longer route at steady highway speeds will often take less gas than going to the same destination along a shorter stop-and-go route.

FUEL EFFICIENCY PERFORMANCE CHECKLIST GUIDELINES

ACCELERATION

1. Accelerating From a Stop

   c = Driver accelerates briskly but smoothly to get into the higher gears as efficiently as possible.

   w = Driver accelerates either too fast or too slow and gas goes unburned or wasted on inefficient lower gears.

SPEED CONTROL - MAINTAINING STEADY ACCELERATOR PRESSURE

Even slight fluctuations in accelerator position can in the long run exact a costly penalty in wasted fuel. The penalty is even larger when momentum is wasted by braking and then re-accelerating, or when accelerating on a hill.

2. Steady Speed on the Open Road

   c = Driver reaches a steady cruising speed and maintains a steady accelerator pressure.

   w = Driver wastes momentum on unnecessary speed changes.

3. Driving With the Flow of Traffic

   c = Driver drives at a speed consistent with the flow of traffic which allows for minimal acceleration, deceleration, and braking.

   w = Driver goes too fast and therefore wastes gas by decelerating or braking and then accelerating again.

4. Climbing a Hill

   c = Driver accelerates before the climb, which provides sufficient momentum to maintain engine speed without further acceleration.

   w = Driver accelerates during the climb to increase engine speed, wasting more gas trying to accelerate against gravity.

OPERATING IN TRAFFIC

Looking well ahead, behind, and to the sides, the driver should maintain a buffer of space between his or her vehicle and surrounding traffic. This enables the driver to anticipate traffic flow disruptions and either avoid them by careful path and speed selection, or else minimize unnecessary gas consumption before coming to a stop.

5. Following Distance

   c = Driver follows at least 2 seconds behind the vehicle in front to leave room to maneuver.

   w = Driver follows too close to the vehicle in front.

6. Approaching a Stop

   c = Driver looks well ahead, quickly spots need to stop, and decelerates early to reduce gas consumption before stopping.

   w = Driver does not anticipate need to stop and unnecessarily maintains accelerator pressure before stopping.

7. Avoiding a Stop

   c = Driver looks well ahead, quickly spots traffic disruption, and either 1) changes lanes or route as early as possible (safely) to avoid stopping or slowing, or 2) slows to a speed which will allow the disruption to be passed with as much retained momentum as possible (and safe).

   w = Driver does not anticipate disruption and unnecessarily stops or loses momentum which must later be regained by additional acceleration and fuel consumption.

FUEL EFFICIENCY PERFORMANCE CHECKLIST

[c]onserving or [w]asteful

RESPONSE RECORD			
#1	#2	#3	
			1. Accelerating From a Stop c = quickly and smoothly w = too fast or too slow
			2. Steady Speed on the Open Road c = steady accelerator pressure w = unnecessary speed changes
			3. Driving With the Flow of Traffic c = with the flow w = too fast
			4. Climbing a Hill c = accelerates before climb/maintains engine speed w = accelerates during climb/increases engine speed
			5. Following Distance c = 2 seconds behind w = too close
			6. Approaching a Stop c = decelerates early w = maintains acceleration
			7. Avoiding a Stop c = changes lanes/retains momentum w = stops/loses momentum

SHORT TRIP PENALTY

NARRATION

1. Payton breaks away from the line of scrimmage.

2. He's up to the 40, the 45--a gain of 15 yards. That gain should really help his rushing average.

3. But wait a minute! There's a penalty! The play is being called back.

4. It's really a pain for a high performer to have his gains wiped out by mistakes.

5. Cars are high performers, too. This car's in good shape. Like a good running back, it's well-tuned and well-cared-for.

6. It has an EPA mileage rating of 21 mpg in the city and 27 mpg on the open road, for an overall rating of 23 mpg.

7. That's the kind of mileage you can get from a fuel-efficient car in the hands of a skilled driver. But, if it isn't used right, it'll pay a high fuel penalty.

8. Even in the best of shape, cars will pay penalties for cold starts, low speeds, and stop-and-go driving--penalties most often associated with short trips.

9. We've equipped our car with a special mileage meter. It tells us how much gas we've used, how many miles we've driven, and what kind of gas-mileage we're getting at any given instant. Let's follow our car on a typical day.

NARRATION

10. This morning we're going to the shopping center for a few quick errands. It's only 2-1/2 miles away.

11. At about a mile into the trip, the meter shows a reading of about 6 miles per gallon. Wow! That's only about a quarter of the car's EPA mileage--not very good. But the engine's still cold.

12. We're almost to the shopping center now, and our mileage is still only 9 mpg.

13. Being at the shopping center for just a few minutes, we spend less time there than the time it took to drive.

14. Now we're on the way home and the mileage is better because the engine's beginning to warm up. Still, the 14 mpg we're getting is little more than half of the EPA rating.

15. Back home. We've gone 5 miles and the meter tells us we've used about a half-gallon of gas. At today's prices, that's a fair piece of change! It may not break us, but we sure expected better from a car with an overall EPA rating of 23 mpg.

16. Okay, it's afternoon now, and we have to make a trip to the University library. This trip is a little longer, so maybe our mileage will be better this time.

17. By sitting out so long, however, our car's become cold again. The gas mileage at the beginning of the trip looks pretty familiar.

NARRATION

18. And as we again drive by the shopping center, we get about 9 mpg, just like before.

19. After 4 miles, however, the car has begun to warm up. We're now getting 16 mpg. Things are looking better.

20. But <u>not</u> when we have to stop.

21. While we're waiting at the stop, for a chance to turn, we're getting <u>zero</u> miles per gallon.

22. Accelerating <u>away</u> from the stop sign, we aren't doing well either.

23. Now we've made it to the University. We've gone the same 5 miles we did on our round trip to the shopping center this morning, and used up the same half-gallon of gas. Only <u>10</u> miles per gallon. But, the engine's pretty warm so we should do better on the return trip.

24. We should, but in stop-and-go traffic, it's pretty tough. We get up to about 20 mpg when traffic's moving, but we lose it every time we have to stop.

25. There's a highway a few blocks over. It's a little out of the way, but maybe we can save some time and gas by using it to get home.

26. We <u>sure</u> can! We are now cruising at 50 mph and getting <u>27</u> mpg--our full EPA-rated highway mileage.

27. As long as we can move at a steady pace with a warmed-up engine, we can get maximum fuel efficiency out of our car.

28. But <u>leaving</u> the highway, our mileage goes back down to about 18 mpg once more.

NARRATION

29. Home again. The meter tells us we went a total of 10 miles and used 3/4 of a gallon of gas. That means we only used 1/4 of a gallon to make the 5-mile trip home. That's twice as good as we did this morning on the trip to the shopping center. Having a warm engine and using the open highway really helps.

30. Tonight we take one more trip to the shopping center. Another 5 miles, and another half-gallon of gas.

31. Let's add it all up. The chart shows that altogether we travelled 20 miles and used 1-3/4 gallons of gas. That means we got only 11.4 mpg in a car that has an overall EPA rating of 23 mpg. Why?

32. There are several reasons. Some of them have to do with a car that's been sitting for a few hours. That's all the time it takes for a car to get cold, even less in cooler weather.

33. One major factor is the fuel mixture. When the engine is cold, a richer mixture is needed, using more gas to do the same work.

34. A second factor is resistance by vehicle parts. When lubricants in the engine, transmission, and drive system are cold, cars get sluggish--a little like we are when we first get up in the morning.

35. A third factor is tire rolling resistance. Air pressure gets a little low when tires are cold. This increases friction, which raises gas consumption.

36. But the car is only one part of the problem. The other part is where it's driven. Most short trips involve a lot of stop-and-go. Even EPA city mileage ratings count on better conditions than this. /// Isn't there any way to defend against the short-trip penalty?

NARRATION

37. Sure there is. Let's go back to today's trips.

38. First, we made two trips to the shopping center. Maybe that was necessary. But, by planning ahead, we might have been able to kill two birds with one stone. That would have saved a half-gallon of gas right there.

39. If we had really gotten our act together, we might have been able to stop at the shopping center on the way to the University. That would have eliminated both trips to the shopping center and saved a whole gallon. Not to mention the half hour of our valuable time we spent driving unnecessarily, and ten miles of the hardest wear we could put on a car--stop-and-go driving with a cold engine.

40. Maybe we can't save two trips every day, but if we saved ten a week, look what could happen in a year! What would we have to give up to save all that gas, all that time, all that wear?

41. Absolutely nothing. Look at today. We could have gotten all the things we needed in just one trip. It just takes a little planning. It just takes the 3 C's.//

42. First, consolidate trips. Don't make two trips to the same destination if you can get everything you need in one.//

43. Second, combine trips. By going straight from one destination to another, this driver saved 3 return trips home.//

44. Consolidating and combining trips saves gas in two ways. First, it raises your mpg by cutting down the number of cold starts, and the miserable mileage you get while the car is warming up. Second, it reduces the number of miles you have to travel--and in stop-and-go traffic, those are the miles that really eat up the gas.

NARRATION

45. Oh, there's one more "C"--confirm. Make sure your trip accomplishes what it is supposed to. Before we took that trip to the library, we called ahead to make sure they had the book we wanted. Otherwise, we might have made a totally useless trip, and simply poured 3/4 of a gallon of gas down the drain.

46. Cutting down on short trips is important. Trips of 5 miles or less make up 15% of the total miles driven by American drivers, but use up 30% of the fuel they consume--that means they eat up twice as much gas as longer trips do. Not surprising from what we saw with the fuel meter.

47. Billions of dollars are eaten up by short trips each year. By following the three "C's," Americans can save themselves a lot of money and their country a lot of fuel. Look what a meager 10% reduction could do.//

48. So try to avoid those short trips.///

49. Make every trip count.

APPENDIX B

FUEL EFFICIENCY MEASURES

This section contains the fuel-efficiency measures used in evaluating instructional methods. The measures include:

> Knowledge Test--The two forms of the 22-item knowledge test.
>
> Attitude Measure--The two forms of the 22-item knowledge test labeled "Fuel Economy Survey-I," Forms A and B.
>
> Attitude Measure--The 16-item attitude measure labeled "Fuel Economy Survey-II."
>
> The Data Recording Form used in assessment of performance at the school and used to evaluate instructional methods.

NAME______________

KNOWLEDGE TEST (FORM A)

Please circle the answer which is most accurate.

1. The most fuel efficient way to warm an engine is to:

   a. Slightly rev the engine for about 1 minute
   b. Idle the engine for about 3-4 minutes
   c. Drive slowly

2. The most fuel-efficient way to start a well tuned, cold engine is to:

   a. Pump the accelerator once or twice before turning the key
   b. Pump the accelerator a few times while turning the key
   c. Hold the accelerator pedal down while turning the key, and avoid pumping

3. Which tires are best for fuel economy?

   a. Convential bias ply tires
   b. Belted bias ply tires
   c. Radial tires

4. A vehicle which goes 10 miles on a gallon of gas when the engine is warm, will go how far on a gallon when it is cold? in

   a. Over 9 miles
   b. About 8 miles
   c. Under 7 miles

5. Your car generally gets the best gas mileage on trips which are:

   a. Under 5 miles long
   b. 5-10 miles long
   c. Over 10 miles long

6. Which of the following practices is most cost-and-fuel-economical?

   a. Making weekly checks to maintain proper tire pressure inflation
   b. Getting an engine tune-up every 12,000 miles or twelve months
   c. Cleaning and adjusting the carburetor each winter and summer

7. Using a synthetic or low-friction engine oil is likely to:

   a. Decrease fuel economy by as much as one mile per gallon
   b. Increase fuel economy by as much as one mile per gallon
   c. Increase fuel economy by as much as three miles per gallon

8. At 50 miles per hour, tires under-inflated by about 8 lbs. will result in:

   a. Increased fuel economy of about one mile per gallon
   b. Decreased fuel economy of about one mile per gallon
   c. No change in fuel economy if pressure is above 20 pounds

9. On multi-lane highways, the best way to avoid unnecessary speed changes is to:

   a. Anticipate the movement of surrounding traffic
   b. Stay in the right-hand lane
   c. Drive about 5 miles per hour below the speed of traffic

10. Driving on the highway with the car windows open will result in:

    a. Increased fuel economy
    b. Decreased fuel economy
    c. No difference in fuel economy

11. The most fuel economical technique for climbing hills in an automatic transmission vehicle is to:

    a. Maintain accelerator pressure but let speed drop off
    b. Apply enough accelerator pressure to maintain speed
    c. Apply enough accelerator pressure to increase speed

12. When compared with a conventional engine, the diesel engine achieves:

    a. Better fuel economy
    b. Worse fuel economy
    c. The same fuel economy

13. With all other factors equal, fuel economy will be improved most if a vehicle is equipped with:

    a. A manual transmission
    b. An automatic transmission
    c. An overdrive transmission

14. Vehicle mileage ratings in the EPA Gas Mileage Guide are based on:

    a. Cross country highway trips
    b. Simulated "trips" in a laboratory
    c. Estimations derived from vehicle specifications

15. For today's vehicles, the factor which affects fuel economy the most is:

    a. Interior space
    b. Weight
    c. Aerodynamic design

16. Which of the following vehicle equipment items has the most effect on lowering fuel economy?

    a. Roof rack
    b. Rear window defroster use
    c. Air conditioner use

17. Which statement is most accurate about mpg differences between vehicle class sizes?

    a. Differences are small (10%)
    b. Differences are moderate (25%)
    c. Differences are large (100%)

18. What is the most important aspect of an engine for fuel economy?

    a. Location
    b. Size
    c. Carburetor type

19. Use of air conditioning will reduce fuel economy most at:

    a. Low speeds
    b. Moderate speeds
    c. High speeds

20. In a standard size car, how much gas can be saved by driving at 55 mph rather than at 60 mph?

    a. 12%
    b. 6%
    c. 3%

21. Which statement is the most accurate about engine wear?

    a. Most wear occurs at speeds above 55 mph
    b. Most wear occurs during the first few minutes after starting a cold engine
    c. Most wear occurs in stop-and-go traffic

22. Which of the following is NOT a fuel economy practice?

    a. Garaging the vehicle during cold weather
    b. Driving with the windows closed
    c. Warming up the engine before driving.

Name______________

KNOWLEDGE TEST (FORM B)

Please circle the answer which is <u>most</u> accurate.

1. Driving in the higher gears you usually:
   a. Get better mpg than in the lower gears
   b. Get the same mpg as in the lower gears
   c. Get worse mph than in the lower gears

2. The most fuel efficient speed range for the average passenger vehicle is:
   a. 20-30 mph
   b. 30-40 mph
   c. 40-50 mph

3. When going up hills, it is most fuel-efficient to:
   a. Maintain a steady road speed (mph)
   b. Maintain a steady engine speed (rpm)
   c. Increase road and engine speed

4. For different make and model cars in the same size class, mpg ratings:
   a. Are about the same
   b. Vary by up to 50%
   c. Vary by 100% or more

5. The most fuel-efficient manual transmission to have for highway driving is:
   a. 3 speed
   b. 4 speed
   c. 5 speed

6. Giving a badly tuned engine a tune-up could improve gas mileage by as much:
   a. 10%
   b. 20%
   c. 40%

7. Tires with pressure 2-3 pounds below the recommended range will result in:
   a. Better fuel economy
   b. Worse fuel economy
   c. No change in fuel economy

8. Inflating tires to the upper end of the manufacturer's recommended range for pressure will:
   a. Increase fuel economy
   b. Decrease fuel economy
   c. Not change fuel economy

9. Brake usage is most likely to <u>reduce</u> fuel economy when a vehicle
   a. Travelling uphill
   b. Travelling downhill
   c. Travelling on a flat surface

10. Which of the following is <u>NOT</u> a fuel economy practice?
    a. Keeping a vehicle in a garage at night
    b. Driving slowly the first few miles after starting
    c. Idling for a 2-3 minute engine warmup.

11. On a day-long trip, a vehicle will probably get the <u>worst</u> fuel economy:
    a. At the beginning of the trip
    b. After about one hour of the trip
    c. Near the end of the trip

12. After starting a vehicle on a cold morning, to get the best fuel economy, you should:

    a. Drive off rapidly
    b. Drive off slowly
    c. Allow the car to idle for about 5 minutes

13. The addition of power options would tend to reduce fuel economy the most for:

    a. Cars with small engines
    b. Cars with medium size engines
    c. Cars with large engines

14. Use of air conditioning will reduce fuel economy most at:

    a. 20 miles per hour
    b. 30 miles per hour
    c. 50 miles per hour

15. A new car buyer who wants to achieve the best fuel economy should request:

    a. A standard rear axle ratio
    b. A lower rear axle ratio than standard
    c. A higher rear axle ratio than standard

16. The EPA Mileage Per Gallon label for new cars is:

    a. The actual mileage obtained by the vehicle
    b. A mileage estimate for that model of vehicle
    c. An unreliable manufacturer's advertisement.

17. The trip that would generally offer the greatest fuel economy would be:

    a. A 30-mile trip
    b. A 15-mile trip in the morning and a 15-mile trip in late afternoon
    c. Three 10-mile trips spread over the day

18. Which of the following vehicle options improves fuel economy the most?

    a. Cruise control
    b. Radial tires
    c. Tinted Glass

19. In cold weather, how far do you usually have to drive to reach maximum MPG?

    a. 15 miles
    b. 6 miles
    c. 2 miles

20. Continually varying speed within a 50-55 mph range:

    a. Has little or no effect on mpg
    b. Can reduce mpg 1-2%
    c. Can reduce mpg by more than 5%

21. The most fuel-efficient way to bring a vehicle to a stop is to:

    a. Maintain accelerator pressure, then brake over as much distance as possible
    b. Reduce accelerator pressure as soon as possible, then brake just before the stop
    c. Rev the engine just before the stop

22. During freezing temperature, how much fuel per hour will the average vehicle use while idling?

    a. Enough to go about 30 miles
    b. Enough to go about 10 miles
    c. Enough to go about 2 miles

Name_______________

ATTITUDE MEASURE

Please circle the answer which best represents your opinion.

1. The expense and shortage of gas should affect your driving:

   a. A lot
   b. Some
   c. A little

2. Operating a car fuel-efficiently deserves:

   a. Constant attention
   b. Frequent attention
   c. Occasional attention

3. Trying to drive faster than the flow of traffic:

   a. Is always a waste of gas
   b. Is often a waste of gas
   c. Is sometimes a waste of gas

4. The cost of the extra gas used in driving above the speed limit is:

   a. Very high
   b. Moderate
   c. Not very high

5. If everyone drove within the speed limit, our country's fuel problem would be eased:

   a. A lot
   b. Some
   c. A little

6. When deciding whether or not to drive somewhere, the cost of gas should influence you:

   a. A lot
   b. Some
   c. A little

7. Of the trips people make in their cars every day, how many are really necessary?

   a. Most of them
   b. Many of them
   c. A few of them

8. By planning their daily trips better, people could save:

   a. A lot of gas
   b. Some gas
   c. A little gas

9. Gas savings make proper vehicle maintenance worth:

   a. A lot of attention
   b. Some attention
   c. A little attention

10. When buying a car, fuel economy should be:

    a. The primary factor in your choice
    b. One of the primary factors in your choice
    c. A factor but not primary in your choice

11. I believe the 55 mph speed limit should be:

    a. Strictly enforced
    b. Enforced with some leeway
    c. Not enforced

12. The 55 mph speed limit has contributed:

    a. A lot to fuel conservation
    b. Some to fuel conservation
    c. A little to fuel conservation

13. When going to a party, people should:

    a. Always share rides
    b. Share rides most of the time
    c. Share rides some of the time

14. People should drive their cars:

    a. Only when absolutely necessary
    b. As little as possible
    c. Whenever it's inconvenient not to

15. Extra money spent on gas-saving options for a new car should be recovered in at <u>most</u>:

    a. One years' gas savings
    b. Two years' gas savings
    c. Three years' gas savings

16. Gas savings from buying a smaller car are generally large enough to justify:

    a. A lot of discomfort
    b. Some discomfort
    c. A little discomfort

/_____/
1

Name_______________

Period_____________

Evaluator__________
2

FRIENDLY F.E. SKILL EVALUATION

CHECKPOINTS		DATA (N/A = 99)
START: SCHOOL		/ / / / (pushes gas) 3 4 5
TURN: LEFT ON ALLENTOWN ROAD		
1. Approaching Stop Sign		
a) Last phone pole before stop	6	______ acceleration
	7	______ mph
TURN: RIGHT ON OLD FORT ROAD	8	______ re-accelerates? (0= No, 1= Yes)
2. Accelerating From a Stop		
a) Time to 20 mph	9	______ seconds
b) Time to 30 mph	10	______ seconds (0 = never reach speed)
3. Approaching Stop Light		
a) Signal sign	11	______ acceleration
	12	______ mph
TURN: RIGHT ON INDIAN HEAD HIGHWAY	13	______ green/red (0/1)
4. Steady Acceleration	14	______ re-accelerates? (0/1)
a) Maximum initial pressure (start zone)		A/ RATING /B (1 to 5)
b) Signal sign (end zone)	15 16	____ ____
5. Approaching Stop Light		
a) Signal sign	17	______ acceleration
TURN: LEFT ON LIVINGSTON ROAD	18	______ mph
	19	______ green/red (0/1)
4B. Steady Acceleration		
a-b) Livingston to stop sign	20	______ re-accelerates? (0/1)
6. Approaching Stop Sign		
a) "No Stopping or Standing" sign	21	______ acceleration
	22	______ mph
CROSS: OLD FORT ROAD	23	______ re-accelerates?
7. Accelerating From a Stop		
a) Time to 20 mph	24	______ seconds
b) Time to 30 mph	25	______ seconds (0 = never reached speed)
8. Climbing Hills		
a) Beginning of guard rail	26	______ acceleration
	27	______ mph
b) "Harmony Hill" gate	28	______ acceleration
	29	______ mph
	30	______ re-accelerates? (0 = NO)

APPENDIX C

ANALYSIS OF VARIANCE TABLES FOR PERFORMANCE MEASURES

In the following tables:
Level 1 = Control Group
Level 2 = Classroom Group
Level 3 = BTW Group

APPROACHING STOP (Average mph)

SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARE	F-RATIO	PROB
A(2)	2	47.4676	23.7338	3.00827	.052
ERROR	112	883.626	7.88951	1	
ADJ. TOT.	114	931.093	8.16748	0	

MODEL R-SQUARED: .0509805

TABLE OF TESTS ON CONTRASTS

	CONTRAST VALUES	ESTIMATE	SUM-SQR.	F-RATIO	PROB
A1	-2 1 1	-.266668	12.8694	1.63121	.198
A2	0 -1 1	.634155	35.7192	4.52743	.013

TABLE OF ADJUSTED MEANS FOR VARIABLE 48

	N	MEAN	SD
FACTOR A(2)			
LEVEL 1	26	31.6143	2.57607
LEVEL 2	42	30.1802	2.99772
LEVEL 3	47	31.4485	2.75538

AVERAGE TIME TO 20 MPH

SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARE	F-RATIO	PROB
A(2)	2	5.27281	2.6364	.924655	NS
ERROR	112	319.338	2.85123	1	
ADJ. TOT.	114	324.61	2.84746	0	

MODEL R-SQUARED: .0162435

TABLE OF TESTS ON CONTRASTS

	CONTRAST VALUES	ESTIMATE	SUM-SQR.	F-RATIO	PROB
A1	-2 1 1	-.0618588	.6925	.242878	NS
A2	0 -1 1	-.224625	4.48153	1.57179	.211

TABLE OF ADJUSTED MEANS FOR VARIABLE 50

	N	MEAN	SD
FACTOR A(2)			
LEVEL 1	26	8.01771	1.29888
LEVEL 2	42	8.05676	1.78618
LEVEL 3	47	7.60751	1.78364

AVERAGE TIME TO 30 MPH

SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARE	F-RATIO	PROB
A(2)	2	75.9195	37.9598	2.32187	.101
ERROR	112	1831.07	16.3488	1	
ADJ. TOT.	114	1906.98	16.7279	0	

MODEL R-SQUARED: .0398113

TABLE OF TESTS ON CONTRASTS

	CONTRAST VALUES	ESTIMATE	SUM-SQR.	F-RATIO	PROB
A1	-2 1 1	.178385	5.75879	.352246	NS
A2	0 -1 1	-.895313	71.1969	4.35487	.015

TABLE OF ADJUSTED MEANS FOR VARIABLE 51

	N	MEAN	SD
FACTOR A(2)			
LEVEL 1	26	16.2973	2.84822
LEVEL 2	42	17.7278	3.7202
LEVEL 3	47	15.9372	4.80203

AVERAGE VALUE FOR STEADY ACCELERATION

SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARE	F-RATIO	PROB
A(2)	2	.0597647	.0298824	.036435	NS
ERROR	107	87.7565	.820155	1	
ADJ. TOT.	109	87.8163	.805654	0	

MODEL R-SQUARED: 6.80566E-04

TABLE OF TESTS ON CONTRASTS

	CONTRAST VALUES	ESTIMATE	SUM-SQR.	F-RATIO	PROB
A1	-2 1 1	.0133229	.0316833	.0386309	NS
A2	0 -1 1	.0175806	.0259936	.0316935	NS

TABLE OF ADJUSTED MEANS FOR VARIABLE 52

	N	MEAN	SD
FACTOR A(2)			
LEVEL 1	26	2.9287	.69319
LEVEL 2	39	2.95109	.855114
LEVEL 3	45	2.98625	1.04241

CLIMBING HILLS (AVERAGE MPH)

SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARE	F-RATIO	PROB
A(2)	2	1.69819	.849094	.0991146	NS
ERROR	112	959.481	8.56679	1	
ADJ. TOT.	114	961.179	8.43139	0	

MODEL R-SQUARED: 1.76678E-03

TABLE OF TESTS ON CONTRASTS

	CONTRAST VALUES	ESTIMATE	SUM-SQR.	F-RATIO	PROB
A1	-2 1 1	.0292048	.154356	.018018	NS
A2	0 -1 1	.130668	1.51652	.177023	NS

TABLE OF ADJUSTED MEANS FOR VARIABLE 53

	N	MEAN	SD
FACTOR A(2)			
LEVEL 1	26	33.3613	2.4395
LEVEL 2	42	33.3183	3.20027
LEVEL 3	47	33.5796	2.91421