AC 2011-2165: AN EVALUATION OF AN ELECTRIC DRIVE VEHICLE PROGRAM BASED ON STUDENT MOTIVATION AND LEARNING EFFECTIVENESS

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An Evaluation of an Electric Drive Vehicle Program Based on Student Motivation and Learning Effectiveness

Abstract

Electric drive vehicles (EDVs) are becoming more and more prevalent in today's marketplace. As such, there is a growing demand for engineers and mechanics that understand these specific types of systems. The U.S. Department of Energy recently awarded the Missouri University of Science and Technology and partners funding to develop a large-scale training project. The project includes the development of undergraduate and graduate curricula and programs at the university level and for community college vocational programs for mechanics. The project also includes a public dissemination component, including partners from the St. Louis Science Center. This program began recently, in the fall of 2010.

In order to provide an initial evaluation of a sample of courses in the program a survey was administered to students currently enrolled in undergraduate and graduate courses that are part of the program. One part of the survey focused on the impact of the courses on motivation and engagement, and the other consisted of Felder's Inventory of Learning Styles (ILS) [1]. Results indicated that motivation and engagement, in this context, could be conceived of as consisting of five components: active learning, visual learning, challenge, applicability, and interest. Further, students rated the project courses significantly more positive on these dimensions. Finally, students were found to be near the mid-point on the ILS active/reflective and sequential/global dimensions; while strongly favoring a visual and sensing style on the visual/verbal and sensing/intuiting dimensions respectively.

Introduction

Electric drive vehicles, or EDVs, represent a technology that has gained much attention over the past decade. With the fluctuations in fuel prices as well as more visible pollution and recent disasters, many industries and consumers alike are realizing the need for alternative energies. As these markets continue to grow, demand for qualified engineers and professionals in this field will grow as well. This research is a part of a five million dollar grant awarded by the United States Department of Energy to help fulfill this purpose. This grant will allow the development of educational programs and certifications for professionals, students, and members of the general public interested in the development and applications of electric drive vehicles.

The focus of this paper is to evaluate a sample of engineering courses that make up part of this project.

Motivation and Learning

Motivation is a driving force that provides incentive for accomplishing a task. A quick internet search on "motivation" reveals websites promising to help boost motivation, posters with vivid graphics and an uplifting caption, and online videos showcasing "motivational" speakers. It is clear that motivation is an important factor in human accomplishments. However, researchers are conflicted on what factors impact motivation. Particularly in education, researchers are focusing on what circumstances lead to better motivated, and thus more successful, students.

Research has demonstrated that one method of increasing student motivation is to provide information in a manner that is consistent with a student's learning style. Richard Felder, a pioneer in learning style research as it relates to engineering education, conceives learning styles as consisting of four fundamental dimensions. Each dimension has two styles that are opposite of one another: active and reflective; sensing and intuiting; visual and verbal; and sequential and global [1, 2]. Active learners gain understanding through doing while reflective learners prefer to process information internally. Sensing learners, as the name suggests, receive information through their senses; intuitive learners favor memories, speculation and imagination. Sequential learners process information in bits and pieces; global learners process information in an "all-or-nothing fashion" and are generally neglected by the educational process [2]. Perhaps the most well-known dimension of learning styles with the strongest preference is visual and verbal. Visual learners prefer information they can see, such as charts, graphs, and other visual aids; verbal learners prefer information they hear, whether it be through lecture or discussion.

Learning styles are measured in a number of survey instruments. This paper focuses on Felder's Index of Learning Styles [1]. In this 44-question index, each question presents a scenario in one dimension. The participant must then choose from two responses: one that represents one style/end of a dimension (e.g., active) and one that represents a corresponding style/end of the dimension (e.g., reflective). Eleven scenarios are presented in each dimension and scored by the participant's response. The number of times a participant chooses a response that represents one style is subtracted from the number of times they select the other dimension to reflect the degree of preference for a given learning style, the highest response for each style is eleven. The higher a student's score, the higher the degree of preference for a particular learning style. Felder suggests that everyone has a learning preference in each dimension (favoring one side of the dimension over the other); however the strength of this preference does vary [1]. Further, Felder suggests that learning styles can change overtime if a student is exposed to effective teachers who use a particular learning style [1].

Engineering students, on average, have been found to prefer particular learning styles. These students demonstrate a strong preference for visual learning over verbal learning [3, 4]. Charts, graphs, videos, and other graphics work much better for engineering students than text-based or lecture-based aids. Often students favor active learning techniques. This is especially true for senior students, who are more likely to be interested in the hands-on applications of the material [4]. Active learning techniques may include activities like laboratory work, working in groups, and playing with ideas [1, 2]. Unfortunately, most classroom environments are passive settings with students involved mostly in listening—slightly favoring reflective learners, but not strongly helping either style [2]. Global learning is also preferred in engineering students [4]. Interdisciplinary thinking is much easier for global learners as they tend to be "big picture" thinkers [2]. A long-term learning style mismatch will lead to decreased interest and motivation in students [2]. It is, therefore, important for professors to note the learning style preferences of their students.

Researchers have also found that challenging material leads to increased motivation [5, 6]. However, finding the appropriate degree of challenge is difficult. Without proper challenge, students may lose interest and material learned may atrophy. With excessive challenge, students may become frustrated and distraught. Therefore, challenge is an important factor when studying motivation.

Method

Based on review of the literature, it was decided that the survey instrument focus around learning styles and motivational factors of both the course and the material. Five categories were identified for study: active learning, visual learning, challenge, applicability, and interest. The active learning category was designed to measure the extent to which the student believed the class was interactive and engaging. The visual learning category was similarly designed; it measured how well the student believed the course to apply to visual learners. The challenge category was designed to gauge if the student believed the course to be sufficiently difficult and thought-provoking; similarly, the applicability category was designed to gauge the students' views on whether or not the course would be useful in non-classroom related, "real world" applications. Interest focused on the impact of the courses on student interest in electric powered vehicles in particular, and alternative energy in general.

The survey used in the current study, was adapted from Carlson and Schoch [5] with questions modified, eliminated, and created for these specific circumstances. Participants were asked to rank their agreement with each statement on a Likert scale ranging from one to five. A five indicated strong agreement, while a one indicated strong disagreement. Table 1 displays the questions and the category each was designed to measure.

Statement	**Category**
This course promoted hands-on learning	Active learning
The course was interactive	Active learning
Students in this course had opportunity for active involvement	Active learning
The course was ideal for someone with a visual learning style.	Visual learning
The course focused too much on verbal description and not enough on visualization.	Visual learning
The professor often used visual aids to clarify understanding of the material	Visual learning
This course was easy.	Challenge
This course challenged me.	Challenge
This course was difficult.	Challenge
I feel that I learned a lot of practical information in this course.	Applicability
I found the material in this course to be applicable to real-world engineering.	Applicability
This course prepared me well for a career related to the subject matter.	Applicability
I often come out of the class lecture feeling tired and worn.	Interest
The course material for this course is engaging.	Interest
The course motivated me to learn more about electric drive vehicles	Interest
The course increased my interest in electric drive vehicles	Interest

Table 1. Statements presented in the survey and what each was designed to measure.

Each category was represented by three to four questions measuring it. Each question was then duplicated for measurement against other courses students have taken at the university. These questions were written identically except for the phrase "this course" was substituted by "other courses I have taken at this University". The survey also included Felder's Inventory of Learning Styles [1].

Missouri S&T students that were currently enrolled in an EDV course were selected to participate. The survey was distributed via email and through Blackboard, an online student resource and communication system. The survey was distributed in the last week of the semester and students had three weeks to complete it. Students were encouraged by the teaching professor to participate. Other than giving students the opportunity to provide course feedback, no other incentives or consequences were offered for completing the survey.

Results

Factor Identification

The first step in the analysis was to confirm the factor structure of our survey, based on the five categories described above, by carrying out a factor analysis on 16 items covering student's perceived outcomes. A series of Principal Components analyses with a Varimax rotation were performed, and a five-factor solution was selected, based on our expectations as described above, the clear loadings, and the large amount of variance accounted for by the solution (83%) and the individual factors (23% - 14%). Three items were eliminated due to their statistical or intuitive lack of fit with the solution, so that thirteen items remained for further analyses. The items, and the factors on which they loaded are displayed in table 2.

	Factor/Category				
Item	**Interest**	**Active Learning**	**Visual Learning**	**Challenge**	**Application**
This course promoted hands on learning.		.83			
The course was interactive.		.78			
Students in this course had opportunity for active involvement.		.74			
The course was ideal for someone with a visual learning style			.69		
The course focused too much on verbal description and not enough on visualization.			-.83		
The professor often used visual aids to clarify understanding of the material.			.78		
This course was easy.				-.89	
This course was difficult.				.93	
I feel that I learned a lot of practical information in this course.					.82
I found the material in this course to be applicable to real-world engineering.					.92
The course motivated me to learn more about electric drive vehicles.	.85				
The course increased my interest in electric drive vehicles.	.87				
The course increased my interest in alternative energy.	.92				

Table 2. Questionnaire Items and Factor Loadings

Comparison with other Courses on Campus

Factor scores. The next step was to create factor scores to represent each of these five factors from the items. Factor scores consisted of the mean of the items loading on each factor, with scores being reversed for those items that loaded negatively. Note that students responded to each item on a five point scale ranging from strongly disagree (1) to strongly agree (5).

Comparison of classes. In order to collect information on the degree to which these courses compare to other courses on campus, in terms of these factors, a series of parallel items were included in the survey that asked students these same questions as they related to other classes on campus. So, for example, in addition to the first survey item listed above "This course promoted hands-on learning", students were also asked to respond to the item "On average, other courses I have taken at Missouri S&T promote hands-on learning." A parallel set of factor scores was created to represent students' views on other courses at the university.

Students ratings for the classes associated with the project, and their ratings of other classes were then compared in a series of one-way between-subjects t-tests with class (project versus other) as the independent variable and factor score as the dependent variable.) In four of the five factors, the ratings for the classes associated with the project were significantly more positive, in terms of motivation, and in the other case (visual learning) the mean for the project class was higher, though not significant. These results are displayed in Table 3.

Factor	Class	
	Project Course	Other Courses
Active Learning**	3.77	3.46
Visual Learning	3.35	3.18
Challenge*	3.64	3.35
Application*	3.93	3.62
Interest**	3.13	2.56

$*p < .05, **p < .01$

Table 3. Factor Scores as a Function of Course

Learning Styles

Students learning styles items were scored in a manner proposed by Felder [1]. Recall that each score can range from a high of 11 for any given style, which would represent conversely a -11 on the corresponding style. (Felder characterizes these as 11a or 11b, depending on which side of the dimension the individual falls.)

The means for students in this sample were as follows:

- Active/Reflective: .22 (reflective)
- Visual/Verbal: 6.12 (visual)

- Sensing/Intuiting: 3.34 (sensing)
- Sequential/global: .46 (sequential)

Conclusions

The results indicate that students' motivation, in this context, can be conceived of consisting of five basic dimensions: active learning, visual learning, challenge, applicability, and interest. This framework will serve to guide further research in the assessment of this project, where developing motivation and passion for electric powered vehicles is a principal goal.

The results further indicate that students in the project classes perceive their classes to be more "motivational" based on these five dimensions. Student rated their project courses as significantly more motivational on the items that represented active learning, challenge, applicability, and interest, and rated their classes as stronger in visual learning too, though the latter was not significant. This is an important first step for establishing the baseline effectiveness of these courses. Of course, much more work needs to be done focusing on the impact of the courses on specific learning outcomes, and, perhaps most importantly, identifying the factors that moderate the relationship between classroom practices and relevant outcomes. Since this assessment took place in the first year of a five-year study this research will serve as an import baseline study for comparison in course improvement.

In terms of learning styles, the most surprising finding was that this sample of engineering students were relatively balanced with respect to active and reflective learning, when we anticipated scores that more strongly favored the active learning of the dimension. Students also scored near the baseline on the sequential/global dimension, which was also counterintuitive, in that there is some evidence, as reported above, that engineering students tend to be more global. Not surprising, and consistent with expectations, was the fact that the sample scored high on the visual end of the visual/verbal dimension and the sensing end of the sensing/intuition dimension.

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