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Developing a Blended Type Course of Introduction to Hybrid Vehicles

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Abstract

An innovative course of introduction to hybrid vehicles is developed for both associate and bachelor degree programs of engineering technology with automotive concentration. The hybrid vehicle course content includes several topics, such as the rational of hybrid vehicles, propulsion systems, motor/generator, batteries, etc. Hybrid vehicle technology is a new area and developed rapidly in the field of automotive engineering. Students need not only the fundamental concepts, but also the ability to keep up with the latest technology after their graduation. Therefore, a blended course type is employed to help students have a better understanding of the fundamentals and developing their self-studying ability. Topics in the course have three steps of learning. Firstly, on-ground lecture is given in class, where the instructor explains basic knowledge. Secondly, students are required to go to university's desire to learn (D2L) online system and finish the online part of the topic. Thirdly, students come back to the on-ground lecture and discuss in groups and with instructor. After the discussion, the instructor gives students a conclusion of the topic and moves forward to the next topic. A computer simulation class is also given thus students can have a trial of design of hybrid vehicle.

Keywords*: hybrid vehicle, blended type course, online class*

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Introduction

Hybrid vehicle technology has been under development for decades and hybrid vehicles by various automobile companies are now in the market. Consequently, the technology of hybrid vehicles plays a noteworthy role in the field of automotive and mechanical engineering. Therefore, an introduction course on hybrid vehicle is necessary for any program of study in the field of automotive/mechanical engineering and engineering technology, because a basic knowledge of hybrid vehicles turns out to be an essential requirement for students who are seeking a further career in the automobile industry.

An innovative course, introduction to hybrid vehicles, is developed for both associate and bachelor degree programs in automotive/mechanical engineering technology. The course gives students the rationale of hybrid vehicles and the contents cover several topics such as hybrid vehicle system classification, motors and batteries, regenerative braking, drive train systems, and control strategies.

Compared to the conventional courses conducted in the engineering technology programs, the hybrid vehicle course has two main distinguishing features. First of all, the technologies of hybrid vehicle are relatively new topics and still under research and development though several types of hybrid vehicles are already in the market. The systems of knowledge and methods of the design and construction of hybrid vehicles are not completely established and will be updated regularly. What is currently classified as up-to-date knowledge learned by students in class is highly likely to be out-of-date or even biased in a few years. Therefore, the instructor has the responsibility to provide knowledge of hybrid vehicle technologies to the students and train them to have the ability to keep up with the latest technologies by themselves in their future career.

Another feature of the hybrid vehicle course is that a full understanding of the hybrid vehicle technology involves broad fundamental knowledge from various fields, such as automotive, mechanical, electrical, and electronic engineering technology. For that reason, the instructor needs to make sure that students have the basic knowledge required before going deeper in the area of hybrid vehicle technologies, which is time consuming. Obviously, due to the limited time in semester, the instructor doesn't have enough time to go through every detailed theory during class. And cost of time to review the basic knowledge may vary due to individual student.

Considering the above two features, a blended learning method is employed for the hybrid vehicle course. In other words, the class contains two types of sections: on-ground and on-line sections. The blended learning class meets the requirement of this specific course better than the traditional lecture methods.

In this paper, the advantages and challenges of applying the blended learning method in the hybrid vehicle course is discussed in the second section, and the third section demonstrates the class schedule arrangement of this course. In the fourth and fifth sections, a detailed example on hybrid vehicle drive train systems and control strategies is exhibited, and the computer simulation work is demonstrated. Section six shows the student feedback, followed by a conclusion of this paper in the last section.

Proposed Method

Blended Learning Class Type for Hybrid Vehicle Course

Blended learning is usually defined as a mixture of on-ground face-to-face lectures and on-line classes[1, 2, 3]. It is introduced to higher education programs and has a reliable outcome comparable with traditional education methods in specific fields[4, 5, 6]. Moreover, major advantages of blended learning include that it can leave more space for students and improve the engagement[7] between the instructor and students during discussion in on-ground class. For that reason, it is a good opportunity for education in engineering field to encourage students' creative thinking[8], as well as problem solving skills.

Using the blended learning method in a hybrid vehicle course has several advantages compared to traditional learning. First, the on-line portion of the course gives students more freedom for self-learning than does the traditional face-to-face class. This helps students achieve the ability of self-learning and conducting critical thinking and makes students realize the importance of lifelong learning. Further, on-line sections make the class schedule more flexible, thus making it easier to be completed than traditional learning. Students can work on the on-line section readings and quizzes at any time and location which best fit their schedule. Therefore, students who have full-time jobs or family issues are able to finish the on-line materials effectively. Moreover, on-line sections can line-up the knowledge for students at various levels. Various students may need a different amount of effort to get the same outcome. For example, when dealing with mathematics problems, such as calculation of gear ratios, some of the students can easily solve the problems and obtain the correct answers while others may have difficulty and need more time to find the results. In the on-line sections, students are required to finish certain tasks, but the amount of time used to finish the task is not specified. Therefore, each student has the opportunity to design their own study plan which fits his/her situation the best as long as their final achievement meets the target set by the instructor.

Challenge of the on-line sections, on the other hand, is how to make sure that the students will/can finish online materials by themselves. The main problem that most on-line courses are facing is that the instructor has no clue if the students actually work on the on-line sections by themselves or get help from somebody else. Moreover, students may have various self-validation standards and may need assistance to see if they have successfully accomplished the tasks in on-line sections. In this case, a quiz is added to each on-line section and considered as a test of students' achievement in on-line sections. The grades of the quizzes are shown to students automatically right after they submit the results, but the correct answers to the quizzes are invisible. Students can try multiple times in the quizzes until their latest grades are acceptable. On the other hand, the instructor checks every attempt of quizzes by students, obtains statistics of the results which show the situations of students' on-line self-learning progress. The student feedback information can help the instructor prepare and modify the discussion and lecture to be held in the following on-ground class. Discussion in the on-ground class requires the involvement of every student, thus the instructor can verify that the on-line sections are done by the students themselves.

Another characteristic of the blended learning type course compared to the traditional one is that it allows more discussion in on-ground classes, thus improving the engagement between instructor and students. As mentioned above, hybrid vehicle technologies require knowledge from multi-areas and representing the background knowledge one by one in lecture costs a large amount of time. To solve this problem, some of the background knowledge learning and exercises are transferred to the on-line sections and the instructor has more time in on-ground class to conduct face-to-face discussion. The contents of discussion are prepared by the instructor based on the feedback gathered in on-line class, thus those on-line tasks which are successfully accomplished by all the students can be neglected, and the discussion emphasizes the problems and questions which are still unclear or controversial. In this way, the on-ground class can be conducted effectively. The class environment is relaxed and the discussions are more interesting and attractive to the students, thus the students get a deeper impression and better understanding of the topics in blended learning mode than in the traditional lectures.

Class Schedule

The hybrid vehicle course is three semester hours credit and is a core course for both the associate and bachelor degree in automotive engineering technology. The course is considered as advanced level for both degrees due to the advanced nature of the technologies involved. Students are allowed to enroll in the course only after completing an advanced course in automotive electronic systems and a course in automotive computerization and systems monitoring.

A bi-month, eight weeks, accelerated semester is held in the department of engineering technology. Sixteen classes are conducted for each offering of the hybrid vehicle course with each offering consisting of nine on-ground classes at two and a half hours per meeting, four on-line classes, one computer class using maplesim[9], and two examinations. The "blended" version of this course was first offered during the summer semester of 2012 and has been repeated four times until now (twice a year).

The course mainly covers four topics: (1) the introduction to hybrid vehicle and system classifications, (2) motor, battery, and regenerative braking, (3) drive train systems and control strategies, and (4) case study of the Toyota Prius.

A detailed schedule of the hybrid course, which is also given to students on the first day of class, is shown as followed:

Class 1: Course introduction. An introduction to hybrid vehicle
Class 2: System classifications and theory of design
Class 3: *Online* (Hybrid systems in market and under development)
Class 4: Motor and battery
Class 5: *Online* (Batteries for electric cars: challenges, opportunities, and the outlook)
Class 6: Electric hybrid power systems
Class 7: Regenerative braking;
Class 8: Midterm exam
Class 9: Coupling technology
Class 10: *Online* (Drive train design for various types of hybrids)
Class 11: Coupling technology and control strategies

Class 12: Computer Lab Class (Introduction to hybrid vehicle design with MapleSim software)
Class 13: Hybrid system optimization and constraints for performance improvement
Class 14: *Online* (Case study)
Class 15: Discussion about case study, Student presentation
Class 16: Final exam

Note: a blended schedule is used in this course, and there are four online sessions during the semester. In the online sessions, the student is required to finish the reading assignments, do the quizzes, and bring their feedback to on-ground sections.

Each student in A.A.S. Program will be required to give an in-class presentation relative to the course content. Each student in B.S. Program will be required to write a research report relative to the course content and give an in-class presentation on it.

Topics covered in this course usually involve three steps:

Firstly, the instructor gives an introduction to this specific topic and explains the fundamental theories and basic knowledge in the on-ground class and makes sure the students have the ability to finish the on-line class by themselves.

Secondly, students are required to complete the on-line class by themselves. A "to-do-list" is posted online in the D2L system. The on-line to-do-list includes self-reading, a quiz covering the previous class content and the self-study materials, and open questions left to students. The self-reading materials may be background knowledge which was not covered by the instructor in on-ground class presentations, an extension of knowledge in the topic, or mathematics problems. After completing the self-reading materials, students will go to the quiz. The quiz is about the theory and knowledge in the previous on-ground class as well as the self-reading materials. Students can attempt the quiz multiple times and the grade of quiz is shown to students automatically after they submit the results of the quiz online. The instructor will collect the quiz results from D2L online systems and prepare for the coming on-ground class. Sometimes, open questions are also left to students in on-line class, and they can be considered pre-homework for student for the coming on-ground class. Students are required to think about the questions and bring their answers to the on-ground class.

Thirdly, in the on-ground class, the instructor asks students to discuss their solutions to the quiz problems and the answers to the open questions in groups. After discussion, a student from each group writes their conclusions on the whiteboard and represents their answers to the other groups. Students put comments and modify their answers on the whiteboard with the help of the instructor and the whole class comes to an agreement at the end. After the discussion section, the instruction provides the class the reference answers to the quiz problems and open questions, followed by a conclusion.

Example

In this section, an example of how to develop the three steps class in the topic of drive train systems and control strategies will be demonstrated.

Step 1: on-ground class

In this class, instructor gives an introduction of the hybrid vehicle drive train system, and completes the following contents:

(1) The relations between speed and torque delivered by mechanical devices;
(2) The speed-torque curves of the engine, motor, and what is desired at the wheels; how to match them;
(3) Fundamental theory and mathematics equations of mechanical coupling devices and the definition of speed and torque coupling; and
(4) Fundamental of electrical coupling.

Step 2: on-line class

In this class, students are required to finish the following to-do-list.

(1) Review of the speed-torque-power curves and the optimal operating region of the engine;
(2) Recall of gear ratio;
(3) Calculate the torque and speed ratio delivered by various mechanical coupling devices such as various gearbox configurations, pulley and chains, and the planetary gear-set. Point out if the devices are speed coupled or torque coupled;
(4) Finish quiz. (an example of quiz is shown in figure 1, and the figure is from supplementary textbook[10]; and
(5) Open question: when designing the hybrid vehicles, we are facing the problem of how to use the two sources (how much, when, etc.). For example, one of the questions we are facing is that if the battery is always fully charged, then there is no space for regenerative braking. How can we design the control strategies to solve this problem? Bring your answer to the next on-ground class.

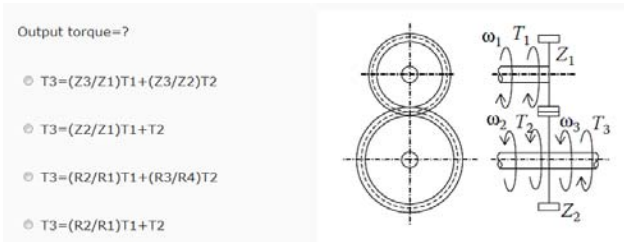

Figure 1. Example of quiz problem in on-line sections

Step 3: on-ground class/discussion

In this class, instructor leads the students to complete the following tasks:

(1) Student group discussion on their answer to quiz, and then the instructor gives the reference answer;

(2) Instructor explains the mechanical and electrical coupling used in the series, parallel, and series-parallel hybrids and introduce various drive train configurations available in design; and

(3) Students discuss their answers to open questions and the instructor introduces two control strategy examples which are maximum state-of-charge of peaking power source and engine turn-on and turn-off control strategies.

Computer AIDED Simulation Class

The computer aided simulation class is added to help student better understand the operation and control strategies of hybrid vehicles, and also give student an introduction of hybrid vehicle design. In the class, students are firstly introduced to MapleSim software, and then asked to design their own hybrid vehicle. The class is held in computer lab, and students work with computers with the help from the instructor. A sample of student work, designing a parallel hybrid vehicle drive train, is shown in figure 2.

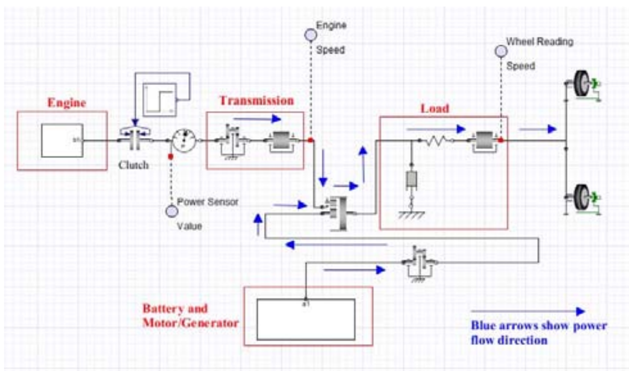

Figure 2. Student work sample for simulation of parallel hybrid vehicle

Results and Discussion

The student outcome and evaluation obtained were considered satisfactory. A satisfactory student self-evaluated outcome is shown in figure 3, in which:

Criteria #1: Students analyse problems, plan and conduct tests, interpret and use test results to develop solutions.

Criteria #2: Students communicate information in written, oral, and graphical forms.

Criteria #3: Students recognize the importance of quality and the need for continuous improvement.
Criteria #4: Students are aware of ethical, social, environmental, and diversity issues; globalization; and the need for lifelong learning.
Student evaluation for the course is shown in figure 4.

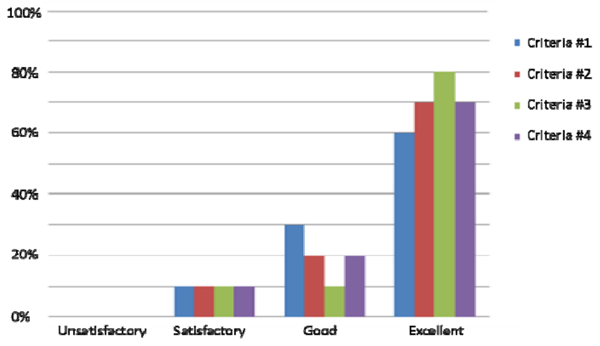

Figure 3. Histogram of student self-evaluation result

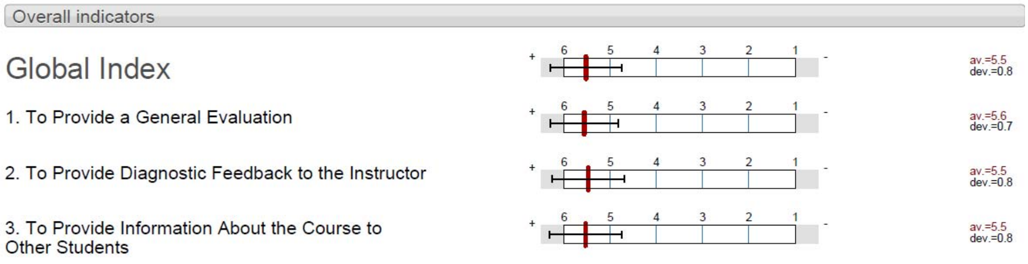

Figure 4. Overall student evaluation result

Conclusion

A new method of applied course offering was developed for an "introduction to hybrid vehicle technology" course and was offered to automotive/mechanical engineering technology students. During implementation of this blended course offering, each step of the process was evaluated and the resulting data used to further refine the blended method of presenting information. The student outcomes and feedbacks provided a high level of validity to this method of material presentation. Though further refinement and improvement of the methodology and course design is needed, based on current results, blended course methodology is a successful method of presenting the tremendous amount of material necessary to introduce students to the large array of technologies necessary to have a thorough understanding of hybrid vehicle theories and systems.

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