Title:

Green Tricycle Design through Experiential Learning — An open courseware enriching engineering curriculum and entrepreneurship

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Introduction:

Aristotle once said, "For the things we have to learn before we can do them, we learn by doing them" [1]. In this paper, an open courseware that enriches engineering curriculum and entrepreneurship by designing a green tricycle through experiential learning is presented. Experiential learning is learning through reflection on doing, a process through which students develop knowledge, skills, and values from direct experiences outside a traditional classroom setting. A green tricycle, which provides short range transportation at low cost, powered by green energy and human power, is employed as a platform to empower students with the practice that brings their idea into reality. This courseware composed of ten lessons guides students to design, analyze, and fabricate prototypes of green tricycles using modern computer-aided technology; as well as develop business plans to bring their ideas into practice through entrepreneurial activity. Students will be able to use their laptops with the computer software tools to design the tricycle following the guidance of the courseware, and use the manufacturing facilities available to them to manufacture prototypes of the tricycle. In addition, a learning community is being created for students to learn from each other by discussing ideas, exchanging lessons learned, and sharing practical experiences. The end result is a great experience for young engineers who become confident in the value of their own ideas and have the tools necessary to bring their ideas into practice and eventually commercial products.

Experiential Learning:

Engineering curriculum is compact at engineering schools in the U.S. Rushing through 130+ credit hours, many with heavy Math and Physics contents, in four years has become a norm to many engineering students who are provided little or no opportunity to put knowledge learned in classroom into practical use. A recent report from the Carnegie Foundation for the Advancement of Teaching [2] examined six US engineering schools and noted a continuing and widespread emphasis on textbook centric theory over hands-on practice, an approach that discourages many students and largely leaves them unprepared for real-world problems.

In order to enrich student learning experience, an open courseware that complements engineering curriculum and promotes entrepreneurship through experiential learning is being created. Experiential learning is learning through reflection on doing, a process through which students develop knowledge, skills, and values from direct experiences outside a traditional classroom setting.

A standard experiential learning model that involves four distinct stages is illustrated in Fig. 1 [3]. In classroom, students learn theory and concept, for example force analysis and material strength in Statics and Solid Mechanics, respectively. With this experiential learning model, students use the theory and concept to design a bridge, designated as the "abstract conceptualization" stage. Students then attempt to build a physical prototype of the bridge in the so-called "active experimentation" stage. In the "concrete experience" stage, students physically experience the bridge under loads. This experience forms the basis for observation and reflection and students have the opportunity to consider what is working or failing (reflective observation), and to think about ways to improve on the next attempt based on the theory and concept learned in classroom. Every new attempt is informed by a cyclical pattern of previous experience, thought and reflection.

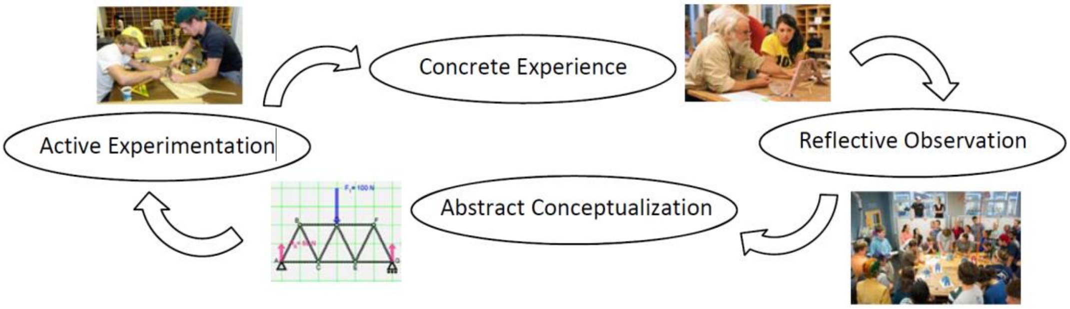

Fig. 1. A standard experiential learning model [3].

Following the standard experiential learning model, an open courseware for the enrichment of learning experiences that integrates engineering curriculum and promotes entrepreneur development and learning community engagement is being developed. Green tricycles, similar to those commercial products of Fig. 2, providing short-range transportation, powered by green energy and human power, are employed as a platform for students to practice engineering knowledge, promote creativity, and pursue entrepreneurship.

Fig. 2. A few commercial products of green tricycles (a) RAHTRACER (www.rahtmobile.com), (b) ELF (organictransit.com), (c) HP Velotechnik (www.hpvelotechnik.com), and (d) LEPUS (www.hasebikes.com)

Green Tricycle:

With the increasing awareness in environmental protection and energy preservation, the demand on green energy powered vehicles is on the rise. Electric or hybrid vehicles are gaining momentum and becoming more popular among consumers. However, battery technology (such as energy capacity), infrastructure (such as charging stations) and high product cost remain challenging in bringing electric cars to household in the U.S. A viable alternative for short-range transportation is green tricycle of low cost, powered by green energy and human power.

A sample tricycle, designed (and being manufactured) by a student team at the University of Oklahoma (OU) shown in Fig. 3, is used as an example to illustrate the details in the design and manufacturing of the tricycle. The sample tricycle features a simple design that aims to keep manufacturing and maintenance costs as low as possible. An aluminum frame of mostly straight and some simply-bent tubing welded together provides structural support for the tricycle, rider and light cargo, making the entire cycle unloaded weigh about 115 lbs. The frame design allows for a recumbent style seat to be adjusted back and forth accommodating riders of varying heights. The tricycle also utilizes a rear steering mechanism unlike most tricycles on the commuter market. This steering arrangement is accomplished by using “push & pull” handles mounted to the frame alongside the driver’s hips. The forward wheels are pedal-powered with adjustable gears for any riding condition. In the event the vehicle's battery is depleted, the rider comfortably completes the journey using pedal power only. Integrated into the rear wheel is a "Magic Pie 5 Vector" by Golden Motor (www.goldenmotor.com) – a motor-and-brake system that is enclosed in a single package mounted to the rear axle, powered by a 2200 mAh battery. This system powers the vehicle forward on its own or with the front pedal assist, dependent on riding conditions (speed, slope, distance, etc.). The Magic Pie 5 Vector also allows the rider to track speed, distance and other metrics through a mounted smart device. The sample tricycle's design is completed by swept-cut acrylic pieces providing a windshield and improved aerodynamics over an open frame design.

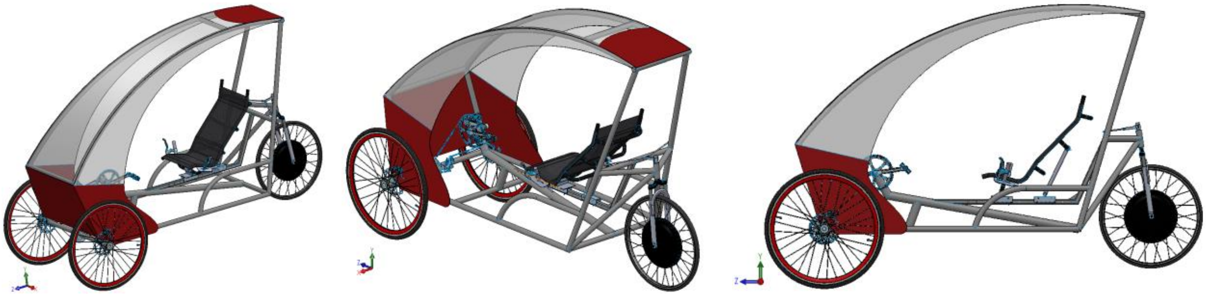

Fig. 3. A sample green tricycle designed by a student team.

The Courseware:
This courseware of ten lessons supports engineering students to put what they learned in classroom into practice by designing and building green tricycles at their own pace. The first seven lessons aim at guiding students to design, analyze, and prototype green tricycles using modern computer-aided technology that enriches engineering design curriculum. Each lesson starts with a short review on basic engineering knowledge taught in core engineering courses and targeting a specific aspect of the green tricycle design (for example, review of major course contents of Dynamics for the design of the tricycle suspension system), followed by sample designs or case studies, and then tutorial lessons that assist students to learn computer-aided design tools that support engineering analysis beyond hand calculations.

The last three lessons focus on the business aspect of engineering product development aimed at supporting and promoting pursue of entrepreneurship. These lessons include U.S. patent applications, business plan development, product cost structure and factory layout for mass production, and fund raising for capital investment.

Using the Dynamics lesson as an example, the courseware establishes a basic understanding of Dynamics concepts like the Newton Laws involving velocity, momentum, force, etc. This is presented in PowerPoint format, easily accessible from the Dynamics link of a website developed to guide students through the engineering design process. There has been much content created at various universities and education institutions that is made available to students free of cost, and the PowerPoint presentations link to these resources. An example of such content is the eCourses at OU (www.ecourses.ou.edu). This content exposes students to an entire university-level course including individual topics like Dynamics. Where the courseware excels however, is through instructed use of engineering tools to solve problems. For example, it is advantageous for students designing a green tricycle to understand how the suspension reacts dynamically to a disturbance (hitting a bump at speed for example). Figure 4 shows a screen shot of SolidWorks being used to analyze the suspension reaction of a simple unicycle. Other included videos show testing the sample green tricycle created by students in a similar video. These screenshots are taken from narrated videos that guide students step-by-step through the process. The narrator provides a general overview of every action, as well as comments on possible pitfalls while using different tools. The narrated videos end by reminding students how and where to ask for help with any issues that may arise along their utilization of the courseware.

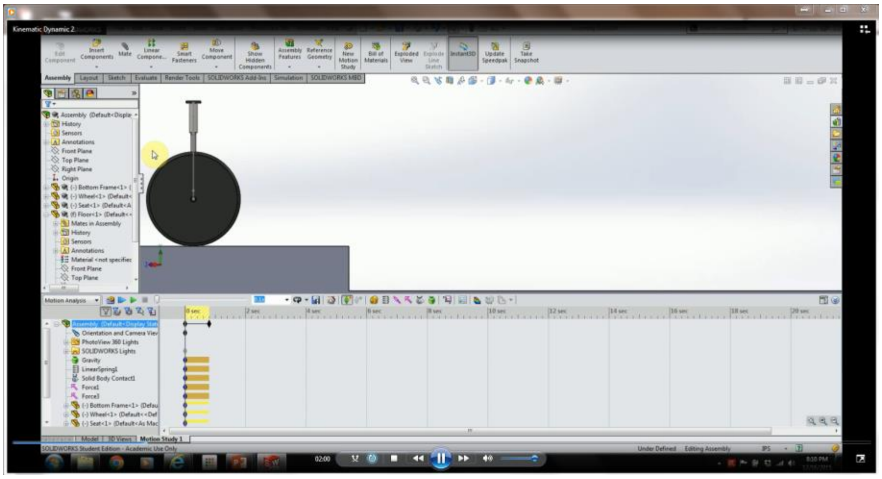

Fig. 4. Narrated video instructions for a unicycle dynamic test.

The courseware soon after developed will be made available on-line for students around the world to review. Students will be able to use their laptops with the guidance of the courseware to design green tricycles using computer software tools. Some will be able to use the manufacturing facilities available to them to manufacture a prototype of the tricycle they designed. The prototype tricycles allow students to physically experience the design of the systems, which offer students the opportunity to consider what is working or failing, and to think about ways to improve on the next attempt based on the theory and concept learned in classroom. In addition, a successful prototype facilitates fund raising for capital investment in pursue of entrepreneurship.

Students may go over the courseware at their own pace. They may choose to go over specific lessons as they march through the curriculum in four years, for example, designing suspension system of the tricycle while taking the Sophomore Dynamics class. A student may spend a summer month of his/her junior year to design the tricycle and the remaining two months to manufacture a prototype. Moreover, instructors may use the courseware as complementary instructional materials and assign components or subsystems of the tricycle design as a final project to enrich students learning experience.

The Website:

The project's website (green-tricycle.com) facilitates a dual role as a free resource for all visitors but is also a system for managing the sample tricycle's parts, assemblies and documentation, accessible only by students currently working on the design and prototype fabrication. It is built upon the WordPress platform that offers many great content management tools for the average manager and web designer. The back-end contains themes and layouts to adjust the look and feel of the website making it as user friendly as possible. It does not require a team of programmers or designers for maintenance and is easily modified and updated by an involved student or volunteer. An initial goal was set for a visitor to recognize every feature of the website simply by reading an element's title or seeing its associated symbol. As seen in Fig. 5, the main website sections are, "Team Portal" which is the management section for currently students active with the sample green tricycle, "Edu.Content" which hosts educational content, i.e. courseware, "GT Design" which highlights the designs of the sample green tricycle and other tricycles designed alongside. The website continues to be developed as feedback is received – ensuring a user-friendly experience.

This website that hosts the courseware also serves as a means that creates a learning community, which encourages students to learn from each other, through the "Community", which is an open platform for discussion. Students are required to register before downloading lessons. The website is designed to provide registered users to not only download the courseware, but also upload the designs, prototypes, lessons learned, technical data, and videos of working tricycles. A chat room is provided for students to discuss ideas, post questions, exchange lessons learned, and share practical experiences. To promote excellence, a green tricycle “hall-of-fame” page (GT Design) will be created to showcase projects successfully completed. These successful projects are incorporated as case studies into the courseware to further enrich student learning experience.

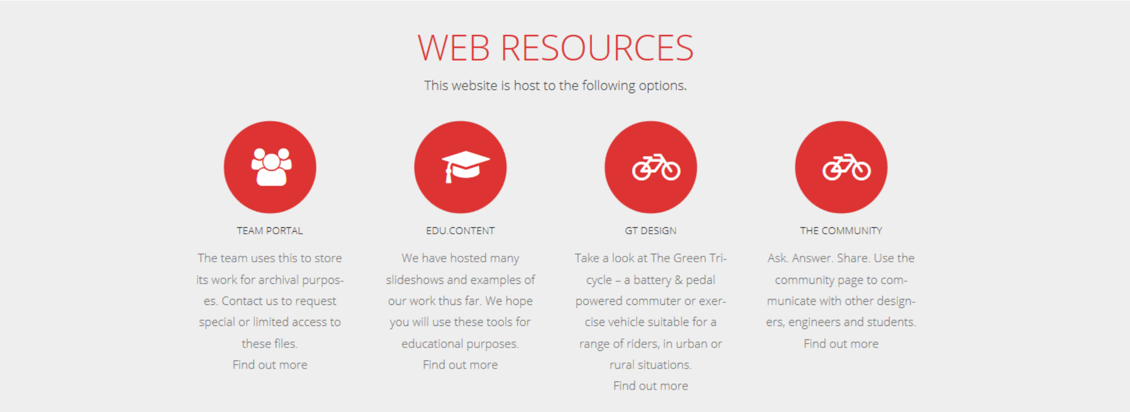

Fig. 5. Resources on landing page of the Green Tricycle website.

Conclusions:

We envision this courseware to provide a great experience for young engineers in the U.S. and around the world a meaningful engineering project as well as an opportunity to pursue entrepreneurship. In addition, a webpage that facilities the creation of an on-line learning community encourages students to learn from each other and promotes excellence. In the long run, as students go over the courseware they become aware of the opportunities to make an impact in the world and confident in the value of their own ideas and have the tools necessary to bring their ideas into practice. Overall, the experiential learning experience enriched by the courseware, the first of its kind, will prepare students to meet global engineering challenges and become successful professionals contributing positively to the global community.

References:

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