Developing and Deploying Flipped Classroom Resources for Renewable Energy Technicians

Mr. Jim Pytel, CREATE and Columbia Gorge Community College, The Dalles, OR

Jim Pytel has taught at Columbia Gorge Community College’s Renewable Energy Technology program since Fall 2008. He has taught the basic electronics series, hydraulics, digital electronics series, introduction to wind energy, motor control, wind turbine safe access and rescue, and power generation classes.

Jim has a Bachelor of Science in Electrical Engineering from Clarkson University in Potsdam, NY. He has worked as an electrical engineer for IBM, Hyundai, ADE Semiconductor, and GE Wind. Additionally, Jim served in the US Army as a Captain in the 4th Infantry Division. He is NABCEP certified for Basic PV and has produced a number of popular flipped classroom resources to supplement his lectures and labs.

He has attended the NSF ATE Basic and Advanced FPGA workshops resulting in the modernization of the digital electronics courses to include HDL and programmable logic devices. Additionally, he has attended the NSF ATE Microcontroller workshop and been a participant in the NSF ATE US-Australia Learning Exchange and US-Germany Learning Exchange. His recent partnership with CREATE has resulted in the YouTube channel "bigbadtech", a channel with an increasing number of flipped classroom resources to support technical education for renewable energy technicians.

Jim sincerely believes energy independence through development of renewable energy sources is the correct course for our nation’s future and actively promotes and supports development of renewable energy projects in the Pacific Northwest.
Developing and Deploying Flipped Classroom Resources for Renewable Energy Technicians

Mr. James Pytel, CREATE and Columbia Gorge Community College

Jim Pytel received a Bachelor of Science in Electrical Engineering from Clarkson University in Potsdam, NY. He has worked as an electrical engineer for IBM, Hyundai, ADE Semiconductor, and GE Wind. Additionally, Jim served in the US Army as a Captain in the 4th Infantry Division. He is NABCEP certified for Basic PV and an ENSA certified Wind Turbine Safe Access and Rescue Trainer.

Jim Pytel has taught at Columbia Gorge Community College's Renewable Energy Technology program since 2008. He has taught the basic electronics series, hydraulics and electrical control of hydraulic systems, digital electronics series, introduction to wind energy, motor control, wind turbine safe access and rescue, and power generation classes and has produced a number of popular flipped classroom resources to supplement his lectures and labs.

He has attended the NSF ATE Basic and Advanced FPGA workshops resulting in the modernization of the digital electronics courses to include HDL and programmable logic devices. Additionally, he has attended the NSF ATE Microcontroller workshop and been a participant in the NSF ATE US-Australia Learning Exchange and US-Germany Learning Exchange. His recent partnership with CREATE has resulted in the expanded development of flipped classroom resources to support technical education for renewable energy technicians.

Developing and Deploying Flipped Classroom Resources for Renewable Energy Technicians

ABSTRACT

This paper presents an alternative format of instructional delivery called a flipped classroom employed by Columbia Gorge Community Colleges’ Renewable Energy Technology program. The flipped classroom approach to instruction uses educational technology to deliver instruction outside the class and activity based learning and lab exercises inside the class. Students watch lectures at the time and place of their own choosing at their own pace and concept engagement and application takes place in the classroom with the guidance of an instructor.

There are several benefits to teaching technical subjects using this delivery format, namely students are offered more control over instructional delivery, the activity based exercises promote student centered learning and collaboration, and the material is made accessible at all times. An online lecture allows a student to learn at their own pace and pause, rewind, revisit, and review material as necessary.

Class time in front of a whiteboard is exchanged for lab time with the guidance of an instructor allowing more hands on time with special equipment and instrumentation. The repository of online lectures is available at all times allowing a degree of flexibility for those students with work or family obligations. A complete, clear, and consistent path is at all times laid out for the
student, clearly indicating what skills must be mastered at what times for success in a course using the flipped classroom approach.

The lab hardware necessary to teach the content delivered in these lectures does not extend beyond that ordinarily found in a traditional electronics lab. Course management software is a recommended means of organizing the content and scheduling activities.

Discussion starts with a review of the challenges faced by both educators and students when teaching and learning technical subjects. Then, the development of the flipped classroom resources is described in detail along with the hardware employed and time commitment necessary as well as recommendations and best practices for the deployment of these resources for a technical program including recommended lab resources. The success of this delivery format has been assessed through a student survey about their perceptions of a hybrid technical course employing online lectures to support a hardware lab.

I. INTRODUCTION

There is a demand for qualified engineers and technicians in manufacturing and energy fields\(^1\) and worldwide interest in renewable energy has increased the connection of intermittent distributed generation to distribution networks.\(^2\) Individuals seeking to enter these career fields must have a requisite knowledge in basic electricity and electronics, mechanics, motor control, and hydraulics for entry level maintenance technician positions\(^3\). Additional career opportunities exist for those individuals skilled in digital electronics, semiconductor devices and circuits, programmable logic controllers, industrial controls, and power generation and transmission.

Traditional instructional delivery methods use a passive learning strategy that features a face to face lecture and a textbook. Students learn concepts during a class with a fixed schedule requiring the physical presence of both the student and the instructor. The textbook is a static repository of information designed to support the concepts discussed in class. Exposure to the subject material is staged, in that basic concepts are progressively built upon and each next concept becomes increasingly complex. Success using this format is predicated upon a student’s understanding of the material at the same rate it is being delivered.

Alternate instructional delivery methods exist with notable advantages\(^4\). The flipped classroom approach to instruction is an active learning strategy that uses educational technology to deliver instruction outside the class and activity based learning and lab exercises inside the class. Students watch lectures at the time and place of their own choosing at their own pace and concept engagement and application takes place in the classroom with the guidance of an instructor. Exposure to the subject material is stilled staged and increases in complexity as the course progresses, however, the lecture content is available for review at all times for those individuals that may miss a class or require repeat exposure to a particular topic. Supporting recitation sessions, workbooks, and pre lab quizzes ensure students have the necessary prerequisites to enter a hardware lab.

Active learning strategies are more effective than traditional passive learning methods in improving students’ conceptual understanding\(^5\) and offer numerous other benefits to both
educators and students. The following paper discusses the development process and deployment of the flipped classroom resources supporting the technical instruction at Columbia Gorge Community College. Additionally, details about the flipped classroom format are presented.

The rest of the paper is structured as follows: Section II reviews the challenges faced by instructors and students in technical fields. Section III focuses on the approach being adopted by the Renewable Energy Technology program at Columbia Gorge Community College. The development and deployment of the flipped classroom resources is described in detail along with the hardware and software employed as well as lab hardware supporting the content. Section IV contains the assessment of the methodology. The paper concludes with closing remarks.

II. CHALLENGES

Both instructors and students face many challenges in technical disciplines.

First, the progressively increasing complexity of technical instruction mandates base skills be mastered before further progress is made. Any disconnect in today’s assigned concept could have disastrous repercussions in later subject comprehension. Any student missing a lecture with a fixed schedule or not fully comprehending the content of one runs the risk of falling behind. Instructors presented with students with remaining questions are often required to perform remedial education at the expensive of other assigned tasks.6

Second, the textbook is a static medium and has limitations to those individuals learning technical subjects. The textbook is a physical object that must be developed, printed, and purchased. Rapid development can quickly outpace material in a reasonably priced textbook7. Additionally, being a static medium, textbook example problems have limited applicability to students seeking guidance on calculation procedures or efficient practices.

Finally, the entire purpose of technical instruction is to prepare students to use common instrumentation and operate, maintain, troubleshoot, and repair equipment. It makes sense that the more hands on exposure a student has to this equipment the better they will be prepared to function in the workforce. Traditional face to face classes compete with hands on exposure time and limit lab and instructor availability to specific periods.

III. OVERVIEW OF THE RET PROGRAM AT COLUMBIA GORGE COMMUNITY COLLEGE

The Renewable Energy Technology Program at Columbia Gorge Community College offers a nine month certificate and a two year associates degree in Renewable Energy Technology. The program was largely based on an existing electricity and electronics engineering technician program, however, was expanded to include mechanics, hydraulics, motor controls, programmable logic controllers, and power generation and transmission at the request of local wind power maintenance organizations. The school received a three year Department of Labor Community Based Job Training grant in 2008 to develop a dual entry program with overlapping cohorts.
The school is geographically located in an area known for prominent wind and hydropower generation sites as well as the Celilo converter station servicing the Pacific DC intertie. Students graduating from the program regularly gain employment with one of the numerous wind turbine operations and maintenance organizations, Bonneville Power Administration, or the Army Corps of Engineers. Additionally, the presence of agricultural processing facilities and unmanned aerial surveillance systems manufacturers seek out graduates of the program for employment since the core skill sets associated with these industries closely match that of the graduates.

The school has two traditional bench electronics labs employing digital multimeters, power supplies, function generators, and oscilloscopes as well as a lab reserved for modular electro-mechanical trainers, motor control trainers, and functional mockups of wind turbine nacelle and a hydraulic and electrically pitched wind turbine hub. The modular trainers can be reconfigured to support both basic and advanced students working in small groups or can be moved into a classroom to support a large group discussion. Additionally, the school has mechanics lab featuring several decommissioned wind turbines for mechanical maintenance exercises as well as industrial scale hydraulics trainers and welding shop.

The prerequisites for the program include WR121 Writing, CAS133 Basic Computer Skills/Microsoft Office, MTH95 Intermediate Algebra and college level reading.

Table 1 shows the course matrix for the current Renewable Energy Technology Program at Columbia Gorge Community College

<table>
<thead>
<tr>
<th>Number</th>
<th>Course Name</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EET 111</td>
<td>Basic Electronics 1: DC Circuit Analysis</td>
<td>5</td>
</tr>
<tr>
<td>MEC 121</td>
<td>Mechanical Power 1</td>
<td>5</td>
</tr>
<tr>
<td>SAF 188</td>
<td>Industrial Safety and OSHA 10</td>
<td>2</td>
</tr>
<tr>
<td>EET 112</td>
<td>Basic Electronics 2: Introductory AC Circuit Analysis</td>
<td>5</td>
</tr>
<tr>
<td>MEC 120</td>
<td>Hydraulics and Electrical Control of Hydraulic Systems</td>
<td>5</td>
</tr>
<tr>
<td>RET 101</td>
<td>Industrial Wind Power</td>
<td>2</td>
</tr>
<tr>
<td>EET 113</td>
<td>Basic Electronics 3: Three Phase AC Circuit Analysis</td>
<td>5</td>
</tr>
<tr>
<td>EET 141</td>
<td>Motor Control</td>
<td>5</td>
</tr>
<tr>
<td>MEC 122</td>
<td>Mechanical Power 2</td>
<td>5</td>
</tr>
<tr>
<td>Second Year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EET 221</td>
<td>Semiconductor Devices and Circuits 1</td>
<td>5</td>
</tr>
<tr>
<td>EET 251</td>
<td>Digital Electronics 1: Programmable Logic Devices</td>
<td>5</td>
</tr>
<tr>
<td>EET 222</td>
<td>Semiconductor Devices and Circuits 2</td>
<td>5</td>
</tr>
<tr>
<td>EET 252</td>
<td>Digital Electronics 2: Programmable Logic Devices</td>
<td>5</td>
</tr>
<tr>
<td>EET 219</td>
<td>Programmable Logic Controllers</td>
<td>3</td>
</tr>
<tr>
<td>EET 242</td>
<td>Microcontroller Systems</td>
<td>5</td>
</tr>
<tr>
<td>EET 273</td>
<td>Industrial Control Systems</td>
<td>3</td>
</tr>
<tr>
<td>RET 102</td>
<td>Alternate Energy Resources</td>
<td>1</td>
</tr>
<tr>
<td>RET 223</td>
<td>Power Generation</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 1: Course Matrix for CGCC RET 2015
A. Objectives of the Renewable Energy Technology Program

The objective of the Renewable Energy Technology Program is to prepare students to work in the field of renewable energy technology. Students may become engineering technicians, hydropower technicians, wind service technicians, or solar technicians. Technicians use electrical and electronic theory to design, build, repair, calibrate, and modify components, circuitry, controls, and machinery. Wind service technicians are responsible for operations, maintenance, and repair of equipment at wind plants. A renewable energy technician might: 1) operate and maintain equipment, 2) perform mechanical and electrical component repair to correct malfunctions following manufacturing requirements, 3) comply with project environmental health and safety programs, and 4) perform preventative maintenance in accordance with original equipment manufacturer (OEM) maintenance manuals.

B. Previous Approach and Associated Challenges

Columbia Gorge Community College previously delivered instruction via a traditional face to face lecture, a textbook, and an associated hardware lab. Students learned concepts during a class with a fixed schedule requiring the physical presence of both the student and the instructor. Assigned readings in the textbook supported the concepts discussed in class. Application of the concepts occurs during the associated hardware lab. Exposure to the subject material was staged, in that basic concepts are progressively built upon and each next concept becomes increasingly complex.

The school received a three year Department of Labor Community Based Job Training grant in 2008 to develop a dual entry program with overlapping cohorts. At one time period two full first year cohorts and two full second year cohorts competed for instructor and lab time and availability. The time commitment required of the instructional staff during this period necessitated researching alternative means of delivering instructional content so lab and workshops could be properly supervised.

C. Flipped Classroom Approach

The flipped classroom approach was used to solve the issues mentioned above. The goal was to deliver quality instruction and still maintain proper supervision in lab.

The flipped classroom is a pedagogical model in which a traditional face to face lecture is replaced with a video lecture to be watched by a student prior to a class session, while in-class time is devoted to exercises, projects, activities, or discussions. The notion of a flipped classroom draws on such concepts as active learning, student engagement, lecture preparation, and hybrid course design. The value of a flipped class is in the repurposing of class time into a workshop where students can apply knowledge, test their skills and interact with one another in hands-on activities. During class sessions, instructors function as coaches or advisors, encouraging students in individual inquiry and collaborative effort.
The first attempt at developing resources for a flipped classroom approach was in the digital electronics series and hydraulics and electrical control of hydraulic systems class. Video lectures were recorded using a digital white board and screen capture software and published on the college’s YouTube channel. Course management software organized the content into units with clear objectives, supporting resources, and reading assignments. Students were assigned a given quantity of lectures to watch prior to coming to lab and a pre-lab quiz ensured students had the requisite knowledge to begin the lab. Similar to a traditional class, the online content was staged such that basic concepts are progressively built upon and each next concept becomes increasingly complex. Students were free from the obligation of attending a rigidly structured class as was the instructor from delivering the content at a set time. The interest in the online content grew outside of the program and the online content has since been updated and expanded.

The NSF ATE project “Developing the Digital Technologist” lead by COSMIAC organized a series of workshops to incorporate FPGA technology into the curriculum of community colleges. As a result, in 2013, the online lectures Columbia Gorge Community College used to support the flipped classroom digital electronics series were updated to introduce programmable logic at the same time as combinational and sequential logic. The new digital electronics 1 and 2 playlists at Columbia Gorge Community College reflect this modernized approach by incorporating programmable devices and HDL early. Additionally, an inexpensive FPGA trainer board has been incorporated into the curriculum that allows students to program the device at home.

In 2014 in cooperation with CREATE Columbia Gorge Community College began to develop and use flipped classroom resources to teach the “EET111 Basic Electronics 1: DC Circuit Analysis” course. These resources incorporate a significant number of basic circuit analysis illustrated example problems, live action videos, applications, and photos of instrumentation and lab experiments. The idea is to continually expose students to common instrumentation and application of theory.

D. Flipped Classroom Resource Development

The online lectures supporting the flipped classroom approach are developed by the instructor using a Dell Latitude XT3 convertible laptop/tablet computer with a stylus. The lectures are predominantly presented using MS One Note and incorporate overlaid still pictures and live action videos of experiments and instrumentation. As needed, software is used to present the topics. Audio is recorded with an external microphone. Camtasia software is used to capture the screen and audio and edit the final product.

Depending on the subject matter complexity and images required, a one hour lecture may require 3-5 hours to script, verify calculations, and capture experimental data, 2-3 hours to record, and 3-5 hours to edit and incorporate imagery. Additional tasks include production, publishing, and maintenance of the playlist which may take an additional one hour. A total of nine to fourteen hours might be devoted to a single lecture. A quarter length course incorporating flipped classroom resources may require forty to fifty such lectures.

E. Flipped Classroom Resource Deployment and Implementation
Columbia Gorge Community College uses Moodle course management software to organize a course using flipped classroom resources. Each course is organized by topics and each topic includes the following data:

- Unit Title and Objectives
- Reading Assignment
- Assigned Online Lectures and Length
- Required Data Sheets
- Alternate Resources
- Worksheets
- Lab (Date, Activity, and Location)

Students are expected to complete the assigned reading, online lectures, and worksheets prior to attending that week’s hardware lab. Students are assessed with a brief pre-lab quiz. Students repeatedly not meeting entry lab requirements are given disciplinary counseling and will be barred from entering further labs if the practice becomes habitual. This clearly places the responsibility on the student to perform the assigned work prior to entering a lab.

Student progress is formerly assessed two to three times each quarter with exams and mandatory practical exercises. Students are routinely asked to demonstrated proper use of common instrumentation. A student cannot achieve a passing grade in the course if they cannot meet minimum requirements of practical exercises. Instrumentation based practical exercises require close supervision of a lab instructor.

F. Lab Hardware Requirements

The lab hardware supporting the “Basic Electronics 1: DC Circuit Analysis” class is customarily found in a traditional benchtop lab and includes a digital multimeter, power supply, protoboard and components for each student group. Additionally, a soldering iron and circuit board projects support board manufacture and repair training. Optionally, modular trainers like the LabVolt EMS system can be used for lab activities with either analog meters or computer based instrumentation and control. Finally, portable devices like the Digilent Analog Explorer can be used to support student exploration and experimentation outside of a lab environment. NI MultiSim is used to simulate circuit properties and allow experimentation outside the lab. Close instructor supervision and interaction is required in the hardware lab.

The lab hardware supporting the “Digital Electronics 1: Combinational Logic and PLDs” and “Digital Electronics 2: Sequential Logic, DSP, and PLDs” class is customarily found in a traditional benchtop lab and includes a digital multimeter, power supply, function generator, oscilloscope, protoboard and components for each student group. Additionally, portable devices like the Digilent NEXYS2 FPGA Development Board can be used to support student exploration and experimentation outside of a lab environment. Software resources include NI MultiSim and Xilinx ISE Design Suite. Close instructor supervision and interaction is required in the hardware lab.
The lab hardware supporting the “Hydraulics and Electrical Control of Hydraulic Systems” class is a modular collection of in line hydraulic components packaged in the LabVolt Hydraulic Systems Trainer 6080 and includes double acting cylinders, directional control valves, pressure relief valves, flow control valves, sequence and pressure reducing valves, check valves, spring loading devices, pressure gauges and flow meters, and pumps. Additionally, a collection of hydraulic components available for disassembly and inspection purposes and hand tools is recommended. When teaching wind turbine technicians, it is a recommended practice to incorporate a completely functional electrically controlled hydraulic system such as brake or pitching mechanisms. Finally, relays, timers, counters, programmable logic controllers, pressure switches, limit switches, and solenoid valves are necessary to teach electrically controlled hydraulic systems. Close instructor supervision and interaction is required in the hardware lab.

G. NSF ATE CENTER RELATIONSHIP

Development of flipped classroom resources is an intellectually demanding and time consuming task and instructors must be incentivized to do so. Instructors must clearly state objectives and ensure a sense of cohesiveness between lectures. The substantial upfront investment, however, yields a product that can be repeatedly employed in many different schools and utilized by numerous students if it is distributed freely.

The resources developed for the “Basic Electronics 1: DC Circuit Analysis” playlist were incentivized for production by CREATE. CREATE is a NSF ATE Regional Renewable Energy Center funded under NSF grant #1002653. CREATE is funding these efforts as part of their curriculum development and dissemination objectives. Several of CREATE’s community college and high school partners have expressed their desire to utilize these materials.

The “Basic Electronics 1: DC Circuit Analysis” playlist took approximately one full year to draft, record, edit, and publish. The content was uploaded to YouTube and has received numerous positive comments and a steadily increasing number of viewers.

IV. ASSESSMENT AND FEEDBACK

In order to evaluate student’s perception of a technical course taught using the flipped classroom approach students were surveyed about the effectiveness of the approach as well how they made use of the resources.

Students were asked:
1) Their perceptions of online learning prior to entering the course.
2) Their level of prior experience with hybrid courses employing the flipped classroom approach.
3) Their perception of this particular hybrid course employing the flipped classroom approach.
4) How often they used the textbook to support the online lectures.
5) Their level of confidence that the course could be taught without a textbook.
6) Their usage pattern of the online resources including where, when, and on what device they watched the online lectures.
7) Their perceived benefits and drawbacks of a technical course employing the flipped classroom approach and any recommendations that could mitigate the drawbacks.
8) Their level of agreement with eight statements made about deployment of flipped classroom resources.

Twenty six out of twenty eight students returned the survey. Seventeen of them were first year students enrolled in a basic electronics class and a hydraulics and electrical control of hydraulic systems class that made use of flipped classroom resources and nine of them were second year students enrolled in a digital electronics class that made use of flipped classroom resources. The first year basic electronics course was only partially taught using flipped classroom resources, however, students were instructed to limit their responses to those subject matters that made use of these resources.

![Figure 1: Student response to the survey question “What was your perception of online classes prior to enrolling in a hybrid technical course with online lectures and hardware labs?”](image)

**Figure 1:** Student response to the survey question “What was your perception of online classes prior to enrolling in a hybrid technical course with online lectures and hardware labs?”

Analysis of figure 1 suggests students have mixed feelings about online courses prior to enrolling in this particular hybrid course.
Figure 2: Student response to the survey question “Have you ever been enrolled in a hybrid technical course with online lectures and hardware labs before?”

Analysis of figure 2 suggests students had little prior exposure to a hybrid course that made use of flipped classroom resources to support hardware labs. This is to suggest that an instructor seeking to develop a flipped classroom approach should very clearly define student expectations at the beginning of the course and differentiate between active and passive learning.

Figure 3: Student response to the survey question “What is your perception of this hybrid technical course with online lectures and hardware labs?”
Analysis of figure 3 suggests students have a positive opinion of the hybrid course they are enrolled in. Factors contributing to the positive opinion will be explored in the perceived benefits of this approach.

![Figure 4: Responses to “How often did you use the textbook during this hybrid technical course with online lectures and hardware labs?”](image)

**Figure 4:** Student response to the survey question “How often did you use the textbook during this hybrid technical course with online lectures and hardware labs?”

Analysis of figure 4 suggests most students only rarely use the textbook associated with the course. This is to suggest that a collection of coherent and organized online lectures can take the place of a static and expensive textbook.

![Figure 5: Responses to “Do you feel a textbook is necessary for this hybrid technical course with online lectures and hardware labs?”](image)
Figure 5: Student response to the survey question “Do you feel a textbook is necessary for this hybrid technical course with online lectures and hardware labs?”

Analysis of figure 5 suggests a majority of students feel a hybrid course using flipped classroom resources can be taught without a textbook. This is to suggest that a collection of coherent and organized online lectures can take the place of a static and expensive textbook.

![Figure 6: Responses to “When do you watch the lectures?”](image)

Figure 6: Student response to the survey question “When do you watch the lectures?”

Analysis of figure 6 suggests students watch the lectures over a broad span of time with a large portion watching the content in the evening. Students were not limited to one choice so the total of responses exceeds the sampled population.
Analysis of figure 7 suggests students overwhelmingly watch the lectures at home, however, several made use of the content at the school library and computer labs. Mobile was meant to imply anywhere with access to wi-fi. Surprisingly one student watched the material at his or her place of employment. Students were not limited to one choice so the total of responses exceeds the sampled population.

**Figure 8:** Student response to the survey question “On what devices do you watch the lecture?”

![Figure 8: Responses to “On what devices do you watch the lecture?”](image-url)

**Figure 8:** Student response to the survey question “On what devices do you watch the lecture?”
Analysis of figure 8 suggests students watch the online content using a broad range of devices including mobile phones with computers being dominant. Students were not limited to one choice so the total of responses exceeds the sampled population.

Student response to the survey question “What benefits does a hybrid technical course with online lectures and hardware labs have over a traditional face to face class?” was difficult to quantify on a graph. A majority of the responses suggest students feel the ability to pause and rewind lectures to be a major benefit of online lectures. Additionally, students appreciate the accessibility and flexibility of such an approach. Students mentioned the reduction in personal expenses in textbooks, travel costs, and commute times. Sample responses include:

“Allows me to space out the learning time and pause or rewind to review.”

“Access to lecture material and examples at all times.”

“The material on the videos are(is) directed, concise and free of many of the distractions that slow down traditional classroom settings. The videos allow me to personalize my learning quickly moving past concepts I understand and easily review what I need to.”

“We come to class with at least a foundation of knowledge to build upon.”

Student response to the survey question “What drawbacks does a hybrid technical course with online lectures and hardware labs have over a traditional face to face class? What steps might be taken to mitigate these drawbacks?” was difficult to quantify on a graph because of the open ended nature of the question.

A number of the responses suggest students feel the lack of the ability to immediately ask a question was a drawback to delivering instructional content using online lectures. Students mentioned an online forum, a lecture outline or a weekly question and answer session might mitigate this drawback. Sample responses include:

“When I had a problem understanding material the opportunity to ask questions was limited. A scheduled study group would be helpful. Outline of the material would be helpful. Additional material, YouTube lecture, websites are helpful.”

“More difficult to ask questions. It may be challenging for some to self motivate to watch the videos, however, weekly quizzes do add some motivation to watching the videos.”

“In some instances it may be a drawback to not be able to immediately ask questions, however, I’ve found the videos and brief pre-lab discussions to be sufficient.”
**Figure 9:** Student response to the survey question Indicate your level of agreement with the following statement: “Online lectures supporting a hybrid technical course with hardware labs are an efficient means of content delivery.”

Analysis of figure 9 suggests students feel online lectures supporting a hybrid technical course with hardware labs are an efficient means of content delivery.

**Figure 10:** Student response to the survey question Indicate your level of agreement with the following statement: “Online lectures supporting a hybrid technical course with hardware labs allow me to learn at my own speed.”

Analysis of figure 10 suggests students feel online lectures supporting a hybrid technical course with hardware labs allow them to learn at their own speed.
**Figure 11:** Student response to the survey question Indicate your level of agreement with the following statement: “Online lectures supporting a hybrid technical course with hardware labs allow me to review and repeat material.”

Analysis of figure 11 suggests students overwhelmingly feel online lectures supporting a hybrid technical course with hardware labs allow them to review and repeat material.

**Figure 12:** Student response to the survey question: Indicate your level of agreement with the following statement: “Online lectures supporting a hybrid technical course with hardware labs allow me to maintain employment while enrolled in school.”
Analysis of figure 12 suggests students feel online lectures supporting a hybrid technical course with hardware labs allow them to maintain employment while enrolled in school. Several students indicated they did not work while in school.

**Figure 13:** Student response to the survey question Indicate your level of agreement with the following statement: “Online lectures supporting a hybrid technical course with hardware labs allow me to manage family obligations while enrolled in school.”

Analysis of figure 13 suggests students feel online lectures supporting a hybrid technical course with hardware labs allow them to manage family obligations while enrolled in school. This may support the conclusion derived from Figure 8 which suggests that the online lectures were frequently watched at home. Several students indicated they did not have family obligations while in school.
Figure 14: Student response to the survey question Indicate your level of agreement with the following statement: “A weekly recitation or study group session would be helpful for a hybrid technical course with online lectures and hardware labs”

Analysis of figure 14 suggests a majority of students feel a weekly recitation or study group session would be helpful for a hybrid technical course with online lectures and hardware labs. The responses derived from the earlier question “What drawbacks does a hybrid technical course with online lectures and hardware labs have over a traditional face to face class? What steps might be taken to mitigate these drawbacks?” support student’s desire to have at least a question and answer session prior to a hardware lab.

![Figure 14: Student response to the survey question Indicate your level of agreement with the following statement: “A weekly recitation or study group session would be helpful for a hybrid technical course with online lectures and hardware labs”](image)

Figure 15: Student response to the survey question Indicate your level of agreement with the following statement: “A workbook would be helpful for a hybrid technical course with online lectures and hardware labs”

Analysis of figure 15 suggests students feel a workbook would be helpful for a hybrid technical course with online lectures and hardware labs. The responses derived from the earlier question “What drawbacks does a hybrid technical course with online lectures and hardware labs have over a traditional face to face class? What steps might be taken to mitigate these drawbacks?” support student’s desire to have a workbook with example problems and solutions supporting the online lectures.
Figure 16: Student response to the survey question Indicate your level of agreement with the following statement: “An outline of notes would be helpful for a hybrid technical course with online lectures and hardware labs”

Analysis of figure 16 suggests students feel an outline of notes would be helpful for a hybrid technical course with online lectures and hardware labs. The responses derived from the earlier question “What drawbacks does a hybrid technical course with online lectures and hardware labs have over a traditional face to face class? What steps might be taken to mitigate these drawbacks?” support student’s desire to have a lecture outline prior to an online lecture.

V. Future Work

Additional flipped classroom resources are being considered for development and older content is being prioritized for update and improvement.

Columbia Gorge Community College’s EET111 “Basic Electronics 1: DC Circuit Analysis” will be fully taught in Fall 2015 using a hybrid format. Students will be assigned a given quantity of lectures and an optional weekly recitation will be held for students to ask questions and practice example problems. Following the recitation students will take a pre-lab quiz and perform a hardware lab on that particular unit’s subject matter. Student suggestions are being considered and some will be implemented in the Fall 2015 academic quarter.

The near term work includes:
1) Lecture outlines will be drafted to support the online lectures.
2) A workbook and answer key will be drafted to support online lectures.
3) Unit assessment quizzes will be drafted to support each unit.

Long term work includes:
1) Development of online content for the “Basic Electronics 2: Capacitors, Inductors, and Introductory AC Circuit Analysis” and “Basic Electronics 3: AC Circuit and 3 Phase AC Circuit Analysis” courses.
2) Updating and improving the “Hydraulics and Electrical Control of Hydraulic Systems” playlist to include more examples, better audio and better edited content.
3) Repurposing content from previous online content to offer custom training for specific career fields or rapid exposure courses.

Further research possibilities include:
1) Can this approach meet ABET learning outcomes?

VI. CONCLUSIONS

Educators can use flipped classroom resources to support a technical course with a hardware lab without a textbook. These resources make the most use of both the lab instructor’s and student’s time. The online content is flexible, accessible, and can paused and reviewed to support the learning process. Commute time, travel expense, and textbook expense for students is dramatically reduced and allows students with family and employment obligations to remain enrolled in school.

This paper presented details related to the background, implementation, development, and deployment of flipped classroom resources for technical courses with hardware labs. Student assessment demonstrated that flipped classroom resources supporting a technical course with a hardware lab are viewed positively. Columbia Gorge Community College’s Renewable Energy Technology program will continue to employ the flipped classroom approach as an alternative means of delivering technical content.

REFERENCES

4 Heidi L. Lujan, Stephen E. DiCarlo “Too much teaching, not enough learning: what is the solution?” Advances in Physiology Education Mar 2006,30(1)17-22;
5 M. Prince: Journal of Engineering Education. 93 (2004) 223