
AC 2011-1196: EET PROJECT SESSION IN A PROJECT LEAD THE WAY CONFERENCE FOR LOCAL HIGH SCHOOL STUDENTS

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EET Project Session in a Project Lead the Way Conference for Local High School Students

Abstract

October 1st, 2010 was the date of Purdue-South Bend's 2nd annual Project Lead the Way Conference for 101 local high school students, giving them some hands-on experience with projects in EET, MET, and IT. There was also a careers session and a campus tour.

This paper provides some general background about the conference and its participants, then describes the EET session in detail, including the student-created project that was its centerpiece. The project, which was created by a sophomore EET student, compares the relative efficiency of two different forms of motor control: resistive and pulse-width-modulated. This project was implemented using Multisim version 11, and the data collection and plotting was performed with MS Excel 2007.

In addition to the project, feedback from the teachers who brought their students to this year's conference is presented, as well as how the EET session format was modified to accommodate feedback from the previous year.

Conference background

Project Lead the Way (PLTW) is an organization that partners with middle schools and high schools across the nation to prepare students for post-secondary education and subsequent careers in Science, Technology, Engineering, and Mathematics (STEM).¹ The Purdue University-South Bend annual PLTW Conference is an outreach program targeting these students from local high schools. The specific goals of the conference are to:

1. Engage them in some fun and interesting activities to spur their interest in technology;
2. Inform them of our degree options available locally, and about related careers;
3. Introduce them to campus; and
4. Motivate better high school study by linking the technical activities to math and science.

The conference is also a nice recruiting tool for this campus. The high school students and teachers enjoy the day and take that excitement back to their respective schools. Moreover, the 2010 conference received news coverage by three local TV stations and the city newspaper. These are big benefits. Although Purdue University is very well-known, people normally associate it with the main campus. Since Purdue-South Bend is integrated into the Indiana University-South Bend campus, many locals are not even aware of our presence in the area. The advertisement serves a dual purpose of raising awareness and informing the local populace of the interesting/exciting activities happening on our campus.

The first PLTW Conference was in the fall of 2009. Twenty students were invited from each of four local high schools. Since two of the schools did not fill all of their slots, there was a total of about 70 participants. In the second go-round in the fall of 2010 the conference was expanded to

accommodate 100 students. One school brought 40 students and the other three brought 20 each. One home-schooler joined the mix, making 101 total student participants.

The day started with a welcome session to introduce the faculty and staff running the conference, then explained the schedule of events for the day. There were five different sessions running concurrently throughout the day: careers information, electrical engineering technology (EET), industrial technology, mechanical engineering technology, and a campus tour. Each session was 25 minutes long, and there was a five-minute break to allow for each group to rotate to the next session. (The 25-minute session length was due primarily to logistics. It allowed fitting the conference inside of the high schools' bus schedules; i.e., each group could use a bus after its morning delivery and still get the bus back to school before time to pick up students in the afternoon.) The focus of this paper is the EET project session. The following sections describe the overall goals and content of the EET session, the project used and how it was developed, delivery of the sessions during the conference while dealing with the news media, and survey feedback from the teachers who brought students.

EET Session

Professor Harding modified the EET session format for 2010 based upon feedback following the 2009 conference. A couple of the teachers who attended the prior year's conference requested more information about EET careers and Purdue's engineering technology curriculum. Those changes required reducing the project time by about 10 minutes to compensate.

For 2010, our goals were to present a few of the industries that use EET students, describe some of the jobs graduates might perform in those industries, engage the high school students in a fun and interesting project, and have them leave with a better understanding of electronics and the importance of a good background in math and science.

The faculty author, who is one of the EET professors, led the 25-minute session. He also arranged for our technician and four EET students to help with the project portion. He began by introducing himself and his supporting cast, then briefly mentioning nine industries that employ EET graduates: aerospace, audio, automotive, biomedical, communications, consumer electronics, military/DoD, power/energy, and test and measurement. Next, he spent a few minutes discussing some of the different jobs they perform, including design, product planning, testing, field applications engineering, sales and sales support, marketing, and various leadership positions. The last thing he discussed before the project was an overview of the four-year EET curriculum at Purdue.

The conference theme was Electric Vehicle Technology, so the authors chose a project that clearly related to electric vehicles. The final 10-12 minutes of the session was dedicated to this project.

EET Project

The goal of the EET project was to demonstrate two different methods of controlling the speed of an electric motor. This was done using Multisim² to simulate the circuits and MS Excel to record and plot the data to compare their efficiencies. The two control techniques were a variable resistor and pulse width modulation (PWM). Both methods can control the speed of an electric motor but PWM is more efficient. If this is applied to an electric car, the increase in efficiency manifests itself as an increase in range for the car using PWM control. This difference is easy to understand.

Since the 25-minute session included information about industries, careers, and the EET academic program, the challenge was to accomplish the project in about 12 minutes while making it entertaining, understandable and hands-on. The authors chose to use a simulation created in Multisim and to have the high school students enter the data into Excel. Running a simulation instead of working on a circuit board had several advantages:

1. The simulation could be built once and copied to all of the workstations.
2. While a hardware circuit broken during the demonstration could be difficult and time-consuming to troubleshoot, a simulation could simply be reloaded.
3. A simulation gives the high school students a preview of the technologies/tools used in industry.

At first the goal was to model an electric car as closely as possible. The intent was to show a real world application of a new technology that would seem relevant and really capture the high school students' attention and ignite their imaginations. There were, however, a few limitations that made a high degree of realism impractical: the conference was only a few weeks away, the EET student doing the project only had one year of study under his belt and needed a substantial amount of supervision, and neither author had any experience simulating motors in Multisim. The project had to be simplified so it was easier to both build and understand. For example, one change was to use a DC motor instead of an AC motor, with a focus on highlighting the two different control mechanisms and how someone in EET might play a part in their development.

Initially, the plan was to have the high school students run two different simulations. The first simulation used variable-resistor control. As shown in Figure 1, one wattmeter was configured to measure the power dissipated in the resistive control (i.e., the rheostat), while the other wattmeter measured the power delivered to the motor. (For the purpose of these simulations, the motors were assumed to have no losses.) The second simulation used PWM control, as shown in Figure 2. Like the first simulation, one wattmeter measured the power lost in the PWM circuitry, while the second wattmeter measured power delivered to the motor. The high school students were then supposed to take data from each simulation, enter them into a spreadsheet, and create a graph of each one. The graphs would visually demonstrate the differences between the two technologies and provide an intuitive way to interpret the data.

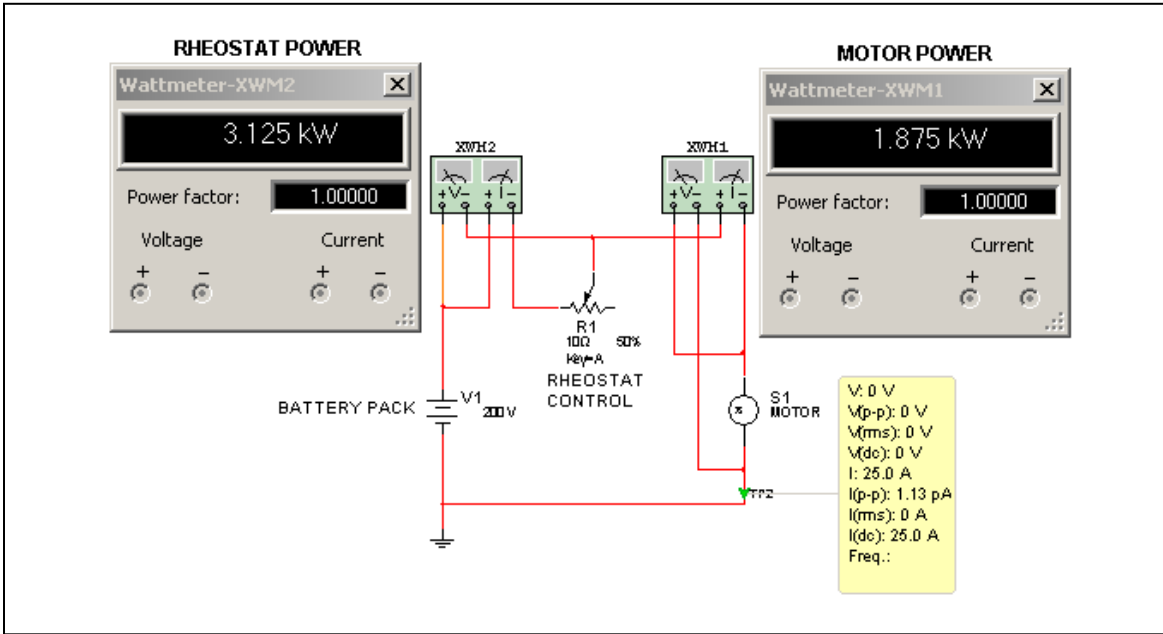


Figure 1: Rheostat Control Circuit

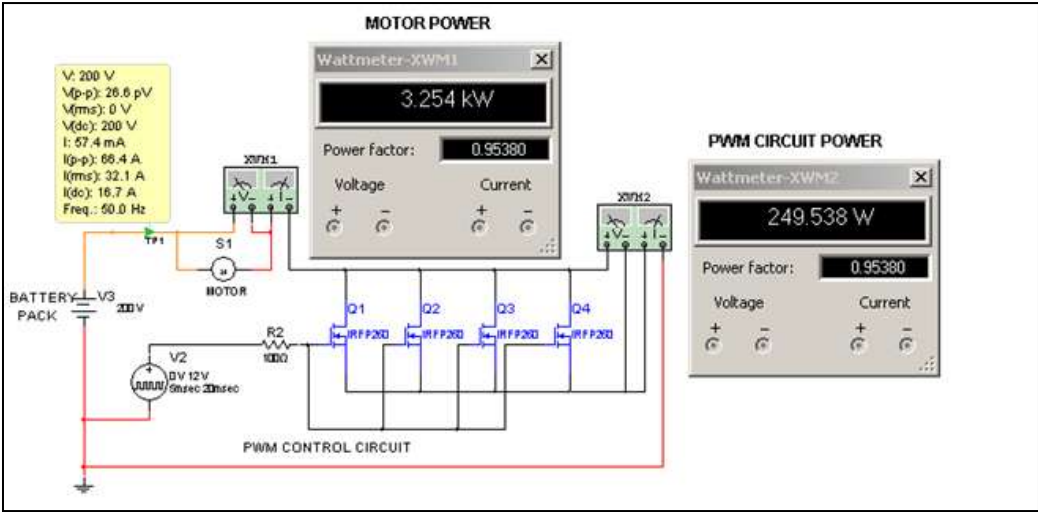


Figure 2: PWM Control Circuit

The EET student author developed a spreadsheet consisting of a data table for each circuit and a plot for demonstrating the difference in efficiency between the two technologies. The high school students were to adjust the rheostat and modify the duty cycle of the pulse generator (see Figure 3), take power measurements from the motor and the control circuitry (see Figure 4) and enter the data into the spreadsheet provided (see Figure 5). They would collect two data points from each circuit. The spreadsheet columns were color coded to better help the high school students understand which columns they were to use. The pink cells (circled in Figure 5) were for the high school students to enter data and the green columns (first and last column in each table) were for the data series they would later enter into a plot. After taking the measurements,

they were to select the data series (see Figure 6) and add a line graph to the plot, which was initially blank except for the axis titles and the legend (see Figure 7). After they collected their own data, and selected both series, they would see a comparison of the two technologies on the plot.

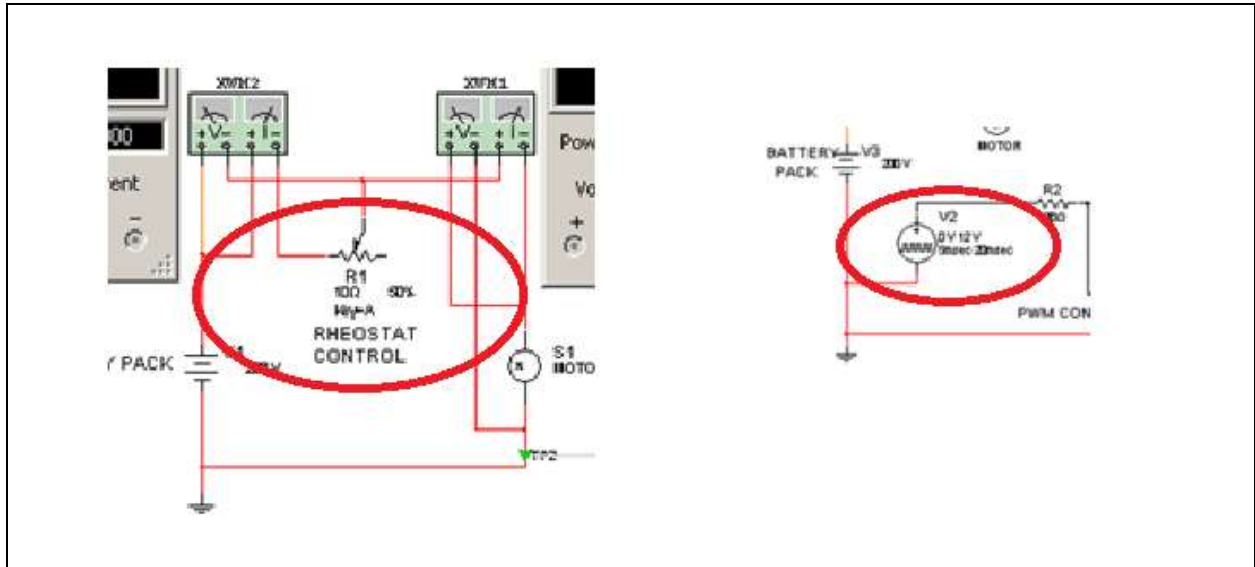


Figure 3: Control Circuits

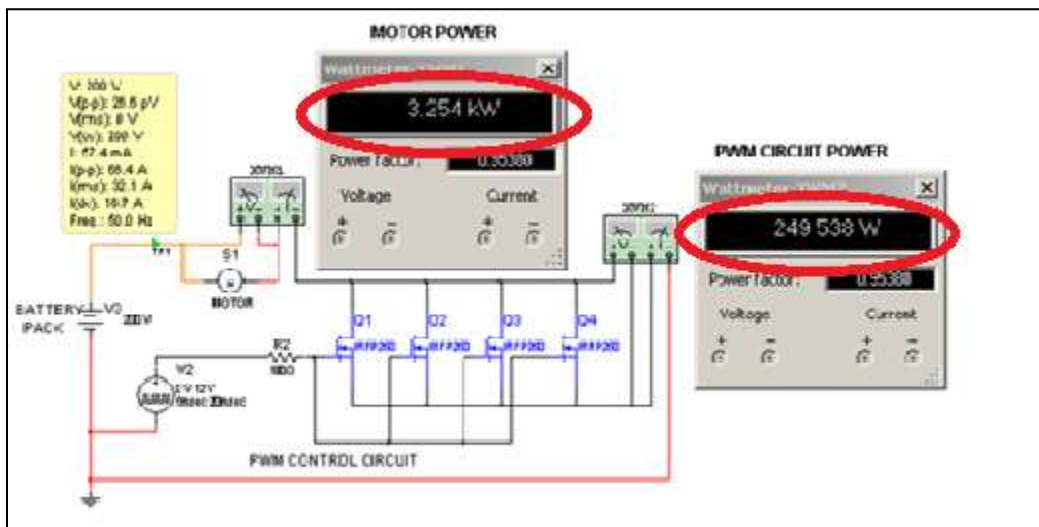


Figure 4: Power Measurements

Pulse Width Modulation Control							Rheostat Control					
Percent Throttle (%)	pwm (%)	Motor Power (kW)	PWM Ckt Power (W)	PWM Ckt Power (kW)	Total Power (kW)	Motor Efficiency (%)	Percent Throttle (%)	Resistor (Ω)	Motor Power (kW)	Rheostat Power (kW)	Total Power (kW)	Motor Efficiency (%)
0	0	0.00	0.00	0.00	0.00		5	10	0.71	2.37	3.08	23.05
10	11	1.20	240	0.24	1.54	84.31	9	7	1.20	2.80	4.00	30.00
0	25			0.00	0.00	#DIV/0!	11	6	1.48	2.06	4.44	33.33
0	50			0.00	0.00	#DIV/0!	0	5			0.00	#DIV/0!
73	75	9.72	230	0.26	9.98	97.39	0	3			0.00	#DIV/0!
100	100	13.25	40	0.04	13.29	99.70	51	1.2	8.00	2.73	9.52	71.43
							56	1	7.50	2.50	10.00	75.00
							73	0.5	9.80	1.63	11.43	85.71
							100	0	13.33	0.00	13.33	100.00

Figure 5: Data Tables for Student Input

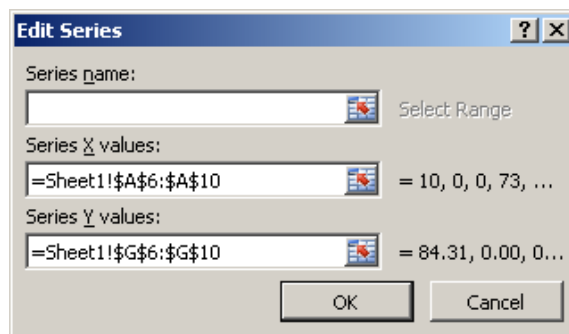


Figure 6: Data Series Entry

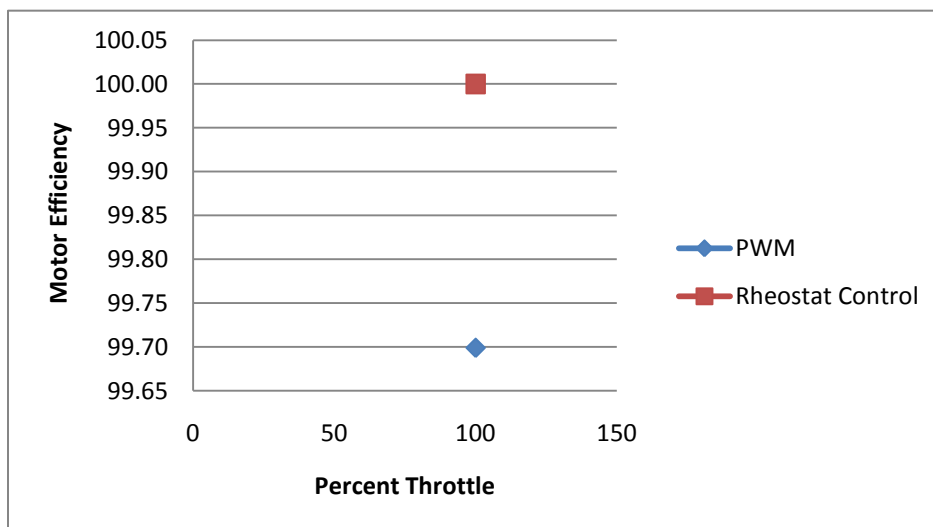


Figure 7: Initial Plot

Once the initial Multisim circuits and Excel spreadsheet were built the authors did a trial run using a couple of volunteers who were not part of the EET program. It became obvious during this first attempt that the time constraint would not permit the quantity of student participation planned, and that there were too many details for the high school students to digest in a short

period of time. The initial expectation was for the high school students to look at two circuits, find the control mechanisms, understand how to adjust the control circuitry, and enter data into a spreadsheet they would be seeing for the first time. Even with the use of an overhead projector and assistants, it was too much. The interactive part of the project had to be scaled back significantly. The value of performing a trial run, well in advance of the project, cannot be overemphasized.

In the modified project, the data for the resistive control circuit was completely filled in and plotted ahead of time (see Figure 8). The high school students were only required to adjust the PWM setting, run a single simulation, record the power levels in the spreadsheet (see Figure 9), and plot the second line graph. The adjustments had several benefits. First, the visual presentation shown in Figure 8 provided an intuitive representation of the motor's efficiency, and effectively framed the rest of the discussion. Second, the simplified approach reduced the probability of student errors. Finally, the simpler task was quicker, so it fit the time frame better.

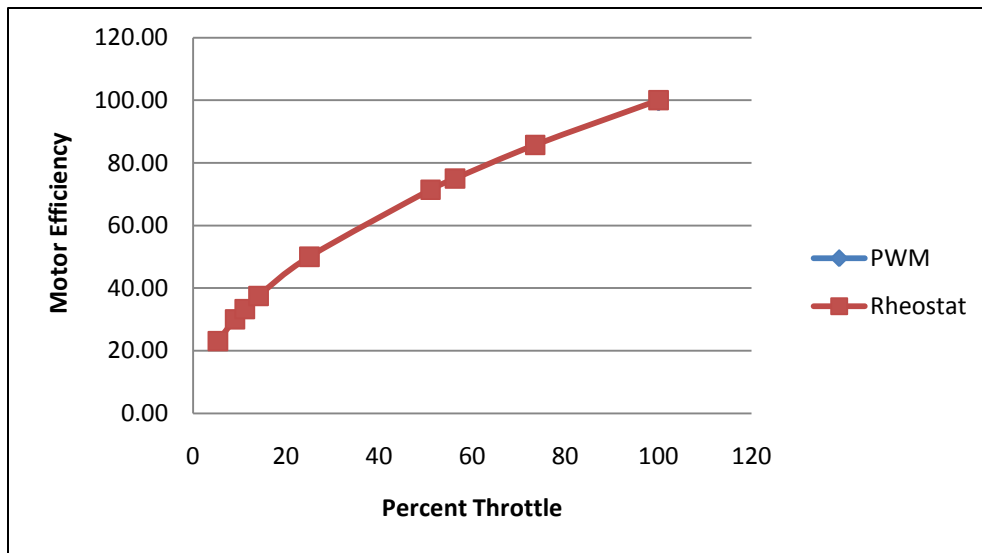


Figure 8: Modified Initial Plot

Pulse Width Modulation Control						
Percent Throttle (%)	pwm (%)	Motor Power (kW)	PWM Ckt Power (W)	PWM Ckt Power (kW)	Total Power (kW)	Motor Efficiency (%)
0	0	0.00	0.00	0.00	0.00	
10	11	1.30	240	0.24	1.54	84.31
25	25	3.25	250	0.25	3.50	92.88
0	50			0.00	0.00	#DIV/0!
73	75	9.72	260	0.26	9.98	97.39
100	100	13.25	40	0.04	13.29	99.70

Figure 9: Adjusted Spreadsheet

As shown in Figure 10, the completed plot clearly shows the higher efficiency using the PWM control technique, particularly at low to moderate throttle settings where most driving is done.

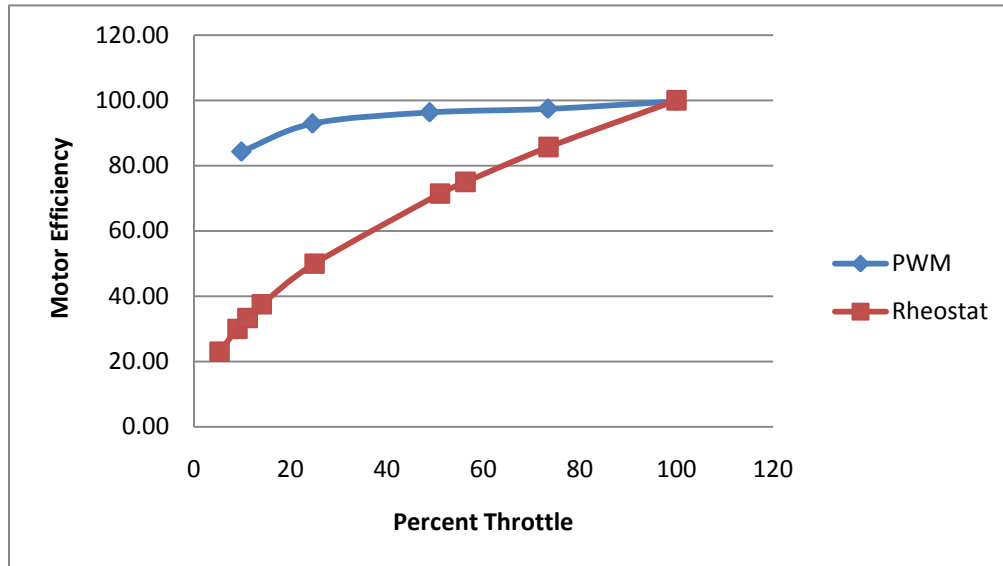


Figure 10: Completed Plot

A major lesson the EET student author learned in the development of the project was the importance of keeping a log. In addition to basic project management guidelines, such as a goal and a timeline, he found that it would have been very beneficial as he developed the circuit to track each change and the rationale behind it. Such tracking is especially helpful after a break from working on a project, when such details may be forgotten.

The final step in the project was preparing the lab computers to be used by the high school students. There were three files used in the project: two Multisim simulations and one MS Excel spreadsheet. Professor Harding placed the final version of each file on the shared network drive, but these files were not used directly for the project. Instead, he created a batch script to copy the files from the network drive to the local computer hard drive (see Figure 11). Before the conference started, he and the EET student helpers put a shortcut to the script and each local file (Multisim and Excel) on the desktop of every computer in the lab. This allowed the EET student helpers to quickly “reload” the necessary files from the network drive, then reopen and reposition each one to get ready for the next group. This was a critical step in the preparation, both to save time and to allow quick recovery should anyone accidentally damage any of the files.

```
xcopy G:\pltw\ECETProjectOutputTables.xlsx D:\* /v /f /y /s
xcopy G:\pltw\PulsewidthModulationControl.ms11 D:\* /v /f /y /s
xcopy G:\pltw\RheostatControl.ms11 D:\* /v /f /y /s

echo off
REM /f displays source & destination filenames while copying
REM /v verifies that files were copied correctly
REM /y suppresses prompting to confirm overwriting files
REM /s copies all subdirectories, unless empty
echo on

pause
```

Figure 11: Script to copy files from shared drive to local drive

Session Delivery

Each session was scheduled to have 20 students. Four students from the university were selected to assist with the project: a freshman, two sophomores, and a junior. Their role was to watch the high school students and help them if they became stuck or lost as they conducted the experiment. Four assistants worked out well to assist the high school students, but no one anticipated the impact of the media presence. During the five-minute break between sessions one and two, then sessions two and three, Professor Harding was interviewed by reporters from two local TV stations. Each time, the interview lasted a bit more than five minutes, which meant someone else needed to kick off the second and third EET sessions to keep us on schedule. Fortunately, our electronics technician, who was also assisting, stepped up to get each session started until Professor Harding could take over. Although ad hoc coverage of the media interviews worked out well, future planning will explicitly account for it to avoid schedule disruptions.

The professor, technician, and all four student helpers thought the sessions went quite well. Three of us (the technician and both authors) were involved with the EET session at the 2009 conference, and all believed this year was more successful than the 2009 version. The key difference, however, was not the project itself. The big difference was the addition of career and academic program information to round out the session. That addition, however, did limit the project time to about 12 minutes, which probably made it easier for the high school students to stay focused. All 101 of the high school students completed the project successfully, and most of them seemed very interested and engaged.

Survey Feedback

Survey Monkey³ was used to gather post-conference feedback because it is free and the online format is easily accessible. This tool (in its free version) limits the survey to ten questions, which was plenty for this purpose. The ten-question limit also increases the probability of response, and the conference planners were pleased to get a response from all four of the high school teachers who participated. For brevity and simplicity, the survey had a minimum of possible responses for each question.

The remaining paragraphs in this section present the survey results for each question. Since the focus of this paper is the EET session, there are no comments here on responses for the Industrial Technology (IT) and Mechanical Engineering Technology (MET) sessions.

The first question asked about the level of technical information (see Figure 12). Three of the teachers thought it was about right for the EET session. One thought there was too much technical material, but did not leave a comment to explain (question 10). Given the overall response, no changes to the level of technical detail are planned if this project is used again.

1. How was the level of technical information in each of the following sessions?				Create Chart	Download
	Too Much	About Right	Too Little	Response Count	
ECET	25.0% (1)	75.0% (3)	0.0% (0)	4	
IT	0.0% (0)	75.0% (3)	25.0% (1)	4	
MET	0.0% (0)	100.0% (4)	0.0% (0)	4	
				answered question	4
				skipped question	0

Figure 12: Question 1 results

The second question was about the amount of hands-on time, which all respondents thought was about right (see Figure 13).

2. How was the amount of hands-on time in each of the following sessions?				Create Chart	Download
	Too Much	About Right	Too Little	Response Count	
ECET	0.0% (0)	100.0% (4)	0.0% (0)	4	
IT	0.0% (0)	75.0% (3)	25.0% (1)	4	
MET	0.0% (0)	25.0% (1)	75.0% (3)	4	
				answered question	4
				skipped question	0

Figure 13: Question 2 results

Question 3 asked for the teachers' impression of how interested and engaged their students were during the activity. All respondents indicated their students were "very" or "moderately" engaged (see Figure 14).

3. How interested and engaged were your students in each of the following sessions?				Create Chart	Download
	Very Engaged	Moderately Engaged	Not Interested	Response Count	
Campus Tour	75.0% (3)	25.0% (1)	0.0% (0)	4	
Careers	50.0% (2)	50.0% (2)	0.0% (0)	4	
ECET	75.0% (3)	25.0% (1)	0.0% (0)	4	
IT	75.0% (3)	0.0% (0)	25.0% (1)	4	
MET	25.0% (1)	75.0% (3)	0.0% (0)	4	
				answered question	4
				skipped question	0

Figure 14: Question 3 results

The fourth question asked about session length, which all respondents thought was about right (see Figure 15).

4. How appropriate was the length of the sessions?			Create Chart	Download
		Response Percent	Response Count	
Too Long		0.0%	0	
About Right	<input type="text" value="100.0%"/>	100.0%	4	
Too Short		0.0%	0	
			answered question	4
			skipped question	0

Figure 15: Question 4 results

One of the sessions was a campus tour. During the conference planning, and following the conference but before the survey, the conference planners discussed dropping the campus tour to lengthen the individual sessions or shorten the conference. Given the survey results (see Figure 16), the campus tour will likely remain in some form.

5. Should we drop the campus tour so we can lengthen the other sessions and/or shorten the conference?		Create Chart	Download
		Response Percent	Response Count
Yes	<input type="text" value="1"/>	25.0%	1
No	<input type="text" value="3"/>	75.0%	3
		answered question	4
		skipped question	0

Figure 16: Question 5 results

Question 6 asked about the amount of academic program information, which was considered to be about right by all four respondents (see Figure 17).

6. How was the amount of academic program information (e.g., specific info about Purdue-South Bend's ECET program), as a proportion of the overall session, for each of the following?				Create Chart	Download
	Too Much	About Right	Too Little	Response Count	
ECET	0.0% (0)	100.0% (4)	0.0% (0)	4	
IT	0.0% (0)	100.0% (4)	0.0% (0)	4	
MET	0.0% (0)	100.0% (4)	0.0% (0)	4	
				answered question	4
				skipped question	0

Figure 17: Question 6 results

The seventh question was about the amount of career information. Each respondent thought it was about right for the EET session (see Figure 18).

7. How was the amount of career information (e.g., what an ECET graduate might do in industry), as a proportion of the overall session, for each of the following?				Create Chart	Download
	Too Much	About Right	Too Little	Response Count	
Careers	0.0% (0)	75.0% (3)	25.0% (1)	4	
ECET	0.0% (0)	100.0% (4)	0.0% (0)	4	
IT	0.0% (0)	100.0% (4)	0.0% (0)	4	
MET	0.0% (0)	100.0% (4)	0.0% (0)	4	
				answered question	4
				skipped question	0

Figure 18: Question 7 results

Question 8 asked how many students each teacher would like to bring. One teacher, at a very large high school with about 3000 students, indicated that he would still bring about 40 (same as this year). The other three schools each brought 20 students, and their teachers indicated that number is about right (see Figure 19). The session allotment will probably stay at 20 students because that is a good size for Purdue-South Bend’s facilities and seems to be a pretty good fit for the participant schools.

8. If you could bring as many students as you wanted, how many would you bring?			Download
			Response Count
			Hide replies 4
1. Still close to 40	Fri, Oct 29, 2010 8:49 AM	Find...	
2. 20-25	Mon, Oct 25, 2010 8:41 AM	Find...	
3. 20 has been good	Mon, Oct 25, 2010 8:07 AM	Find...	
4. 25-30	Fri, Oct 22, 2010 11:28 AM	Find...	
			answered question 4
			skipped question 0

Figure 19: Question 8 results

The ninth question addressed how well conference goals were met (see Figure 20). The “motivate” response was actually better than expected. The “engage” response was somewhat

worse than expected, but probably not because of the EET session. (Two of the other sessions were less hands-on.)

9. How well did we meet our conference goals?				Create Chart	Download
	Very Well	OK	Not so well	Response Count	
Engage students in technology projects	25.0% (1)	75.0% (3)	0.0% (0)	4	
Inform students about careers in industry, Purdue programs, and campus life	50.0% (2)	50.0% (2)	0.0% (0)	4	
Motivate better study and career planning while in high school	25.0% (1)	75.0% (3)	0.0% (0)	4	
				answered question	4
				skipped question	0

Figure 20: Question 9 results

The final question was an open-ended one: “Do you have any other suggestions?” Although three of the four responded, none had a comment relating to the EET session.

As a whole, the survey feedback was edifying, and particularly so for the EET session. Hopefully this project can be reused in 2-3 years with very minimal changes.

Conclusion

In the end, this project turned out to be very successful. It was clear that a simulation project (i.e., no hands-on hardware work) could hold high school students’ interest and meet/exceed the expectations of their teachers. Moreover, 25 minutes proved to be a good length for the overall session, using about 10-15 minutes of the time for the project itself. It should be noted that this was a broad sampling and relatively large number of PLTW students. A longer, more intensive project would be a good fit for a few of the high school students but not the whole group.

A few good lessons became readily apparent during project development and session delivery. First, it was a good move to focus on the big picture, which was a comparison of two different technologies. A lot of effort spent making the motor and its control circuitry more “realistic” probably would have prevented project completion. Second, although handling the media worked out this time, future conferences will include deliberate planning to make sure it does not disrupt the conference operations. Finally, the EET student author learned a couple of lessons: the value of doing a dry run early enough to permit substantial changes to the plan, and the importance of keeping a good log to track progress and avoid redoing work.

Information about this project will be posted on Purdue-South Bend’s web site at <http://www.tech.purdue.edu/SouthBend/Academics/Majors/ecet/Research/index.cfm>. Those

who have questions about the project or conference, or would like a copy of the simulation and spreadsheet files are welcome to email Professor Harding at glhardin@purdue.edu.

¹ <http://www.pltw.org/>, last accessed January 7th, 2011.

² <http://www.ni.com/multisim/>, last accessed January 14th, 2011. Multisim is a schematic capture and circuit simulation software package by National Instruments.

³ <http://www.surveymonkey.com/>, last accessed January 6th, 2011.